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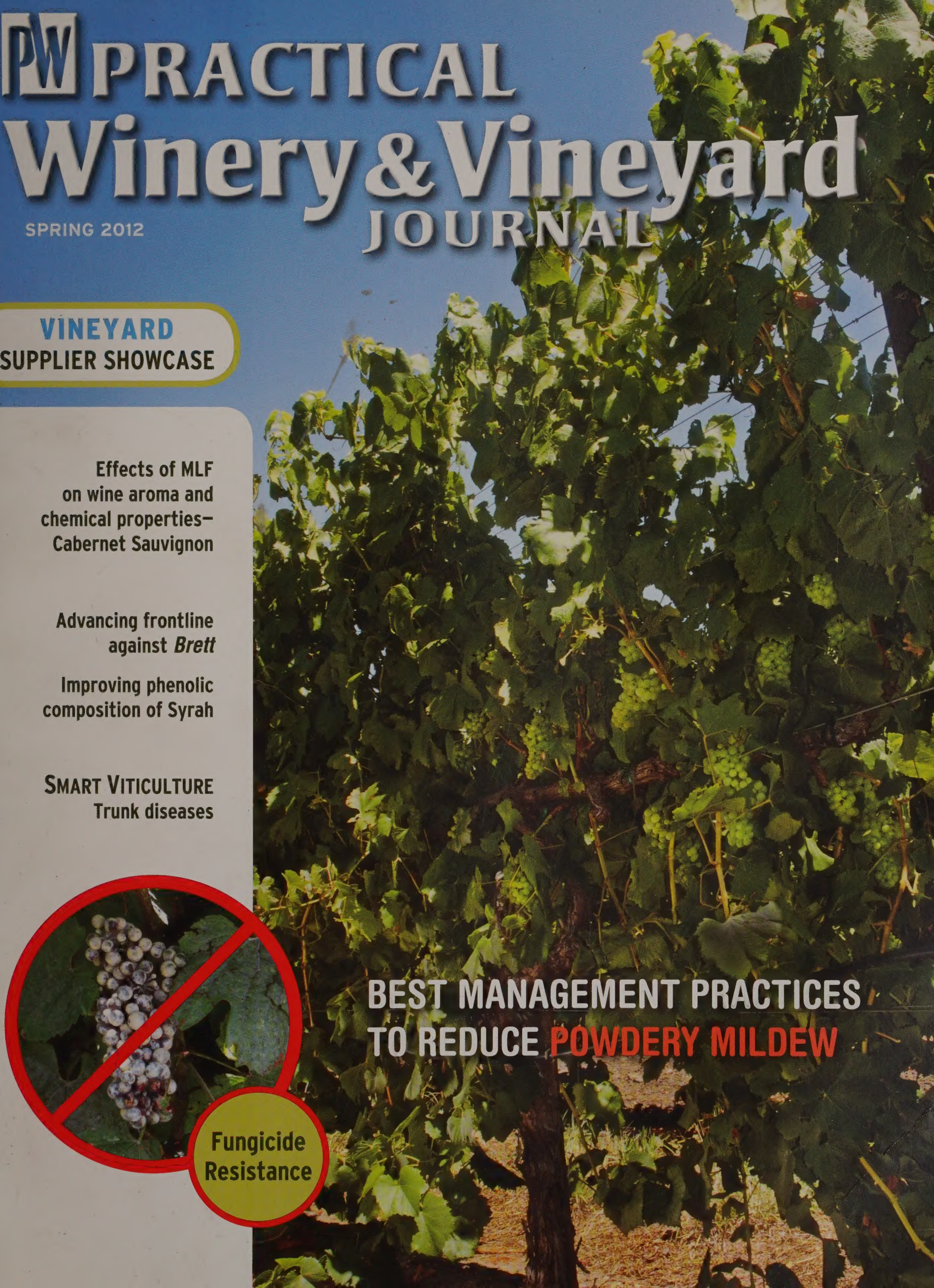

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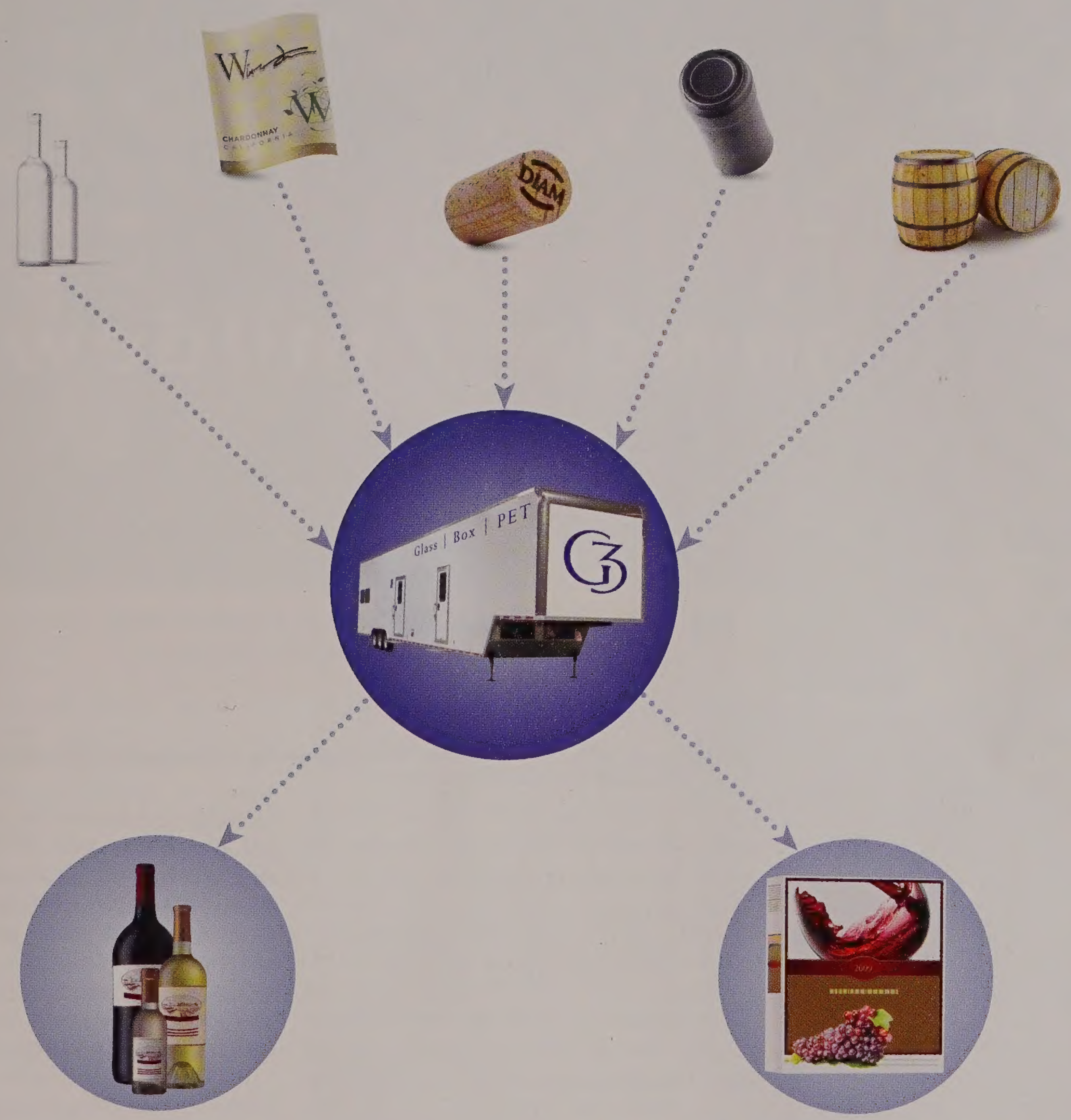

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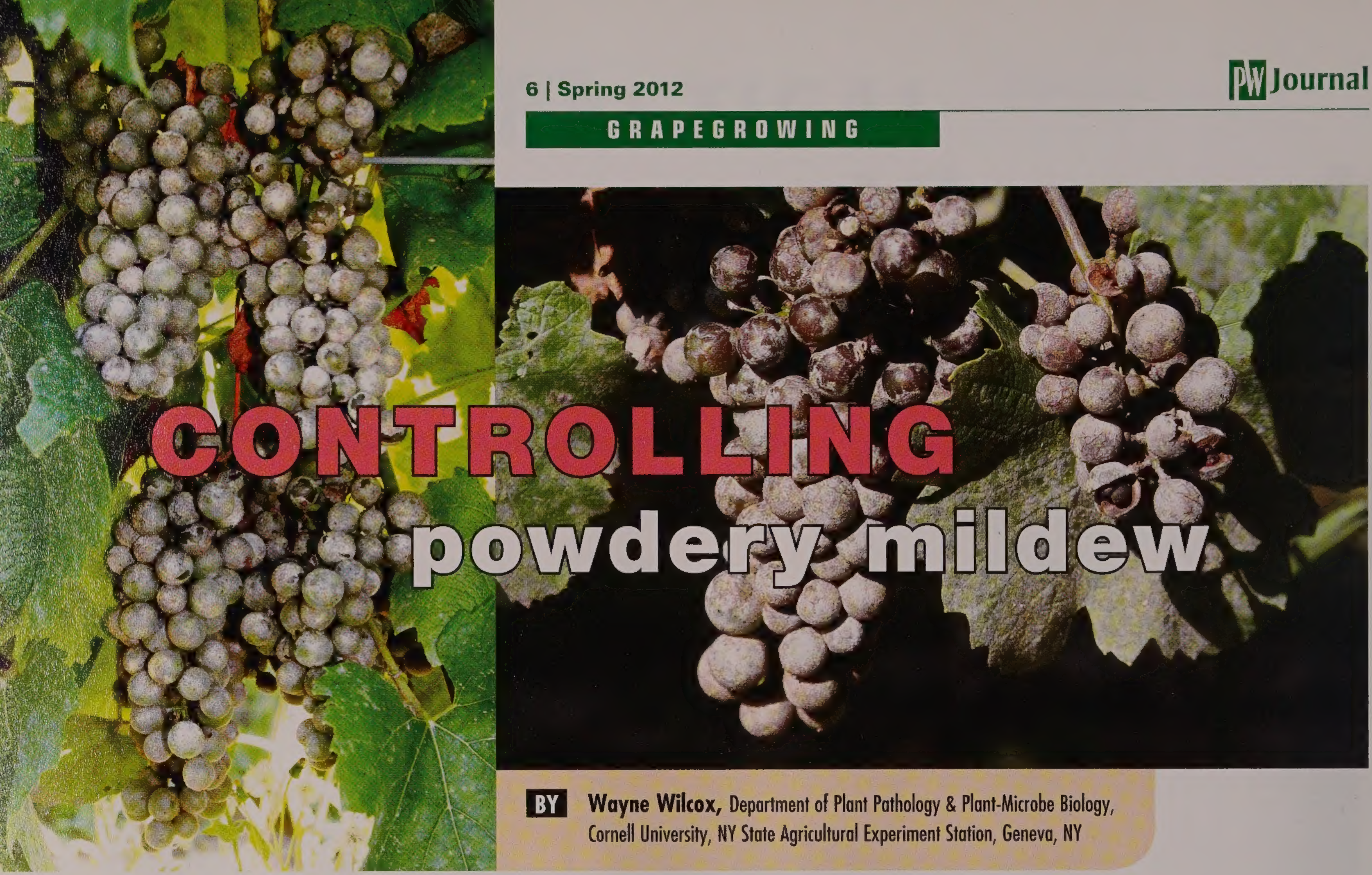
CONTROLLING powdery mildew

BY **Wayne Wilcox,** Department of Plant Pathology & Plant-Microbe Biology, Cornell University, NY State Agricultural Experiment Station, Geneva, NY



Pre-veraison (left) and pre-harvest (right) symptoms of Chardonnay clusters and young leaf severly infected with powdery mildew.

Eastern North America is the ancestral home of powdery mildew (PM), a disease that we fight and research intensively. There are obvious climatic differences between the eastern and western viticultural areas of the continent, but basic biological principles are universal. Applying them to local control programs, however, sometimes needs adjustment. The following summarizes some key points about the biology of this disease and its control in the eastern region, including some recent research findings.

Biology

1) As most growers know, the fungus overwinters either within infected buds (mild winter climates only) or as fruiting structures (cleistothecia) that form on infected leaves and clusters, from which they typically wash onto the bark of the vine and persist until initiating infection the next spring. Thus, the amount of fungus capable of starting disease this year is directly proportional to the amount of disease that developed in the previous year.

To illustrate the practical effect of this, we conducted an experiment in a Chardonnay vineyard where we either a) kept the vines squeaky clean throughout the growing season; b) quit spraying midsummer to let a moderate level of mildew develop; or c) quit spraying in early summer, to allow rampant disease development.

When we intentionally applied a minimal spray program to these vines the following year (starting late and stopping early), the resulting cluster disease severities were a) 11%, b) 22%, and c) 48% of the cluster area infected, respectively, even though all were sprayed exactly the same during the second season. Conclusion: Higher disease in Year 1 led to more primary infections to start off Year 2, which meant that when the fruits were formed and highly susceptible to infection, there were many more new ("secondary") spores. This resulted in much heavier disease pressure to "overwhelm" the fungicide spray program.

Several potential strategies can help those who had serious mildew in 2011. One is to apply lime sulfur during the dormant season to kill many of the cleistothecia on the vines. Unfortunately, this is an expensive and unpleasant task. In the eastern region, it is generally more economical to instead put some of what the dormant lime sulfur application would cost into beefing up the spray program once vine growth begins. Do not push things — start a little earlier than you normally would, do not stretch intervals, do not cheat on rates. But every vineyard is different.

2) Temperature is the most important weather component affecting disease development, which is why it is the heart and soul of the successful UC Davis Risk Assessment model. But it is not the only one.

For example, even though PM can develop under an extremely wide range of humidity, high relative humidity (RH) increases disease severity. We found that disease severity doubled as RH increased from 40% to 80%, which was near the optimum level in our studies. German pathologists claim an optimum of ≥70% RH, those at UC Davis a little bit lower. We all agree on the basic concept that whereas mildew does not need humid conditions to develop, it does thrive under them.

Vineyard sites and/or canopies subject to poor air circulation and increased microclimate humidity, and seasons with frequent rainfalls, provide a significantly greater risk for PM development than their drier counterparts. Thick canopies and rainy seasons are not only associated with high humidity but — even more important — they are also associated with limited sunlight exposure, which greatly increases the risk of disease development (see below).

3) Our research shows that berries are extremely susceptible to infections initiated between the immediate pre-bloom period and fruit set, then become highly resistant to immune about four weeks later. European workers have found the same thing, but this concept reportedly has not held as well in California. Nevertheless, conventional wisdom has always been that berries are particularly susceptible to infection when they are young, and this is when we recommend that growers use their most effective PM fungicides and do not cut corners in terms of spray interval and application technique.

4) Powdery mildew is a unique disease in that the causal fungus lives almost entirely on the surface of infected tissues, sending little "sinkers" (haustoria) just one cell deep to feed. This makes it subject to control by any number of "alternative" spray materials (oils, bicarbonate and monopotassium phosphate salts, hydrogen peroxide, etc.) that have little to no effect on other disease-causing fungi, which live down inside the infected tissues.

Two primary limitations to this group of products need to be considered if you want to use them effectively: a) they work by direct physical contact, so can only be as effective as the coverage you provide; and b) they work primarily in a post-infection/curative mode by killing the fungus right after they hit it, providing only modest (horticultural oil) to no (potassium salts) protection against

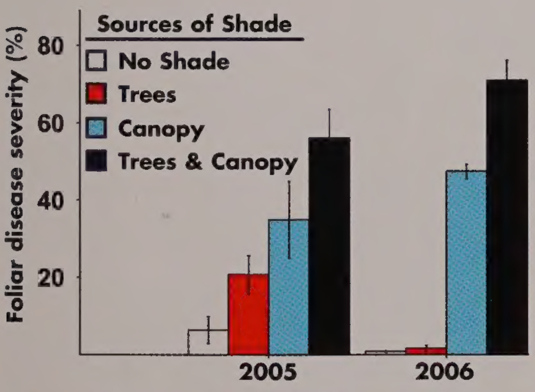
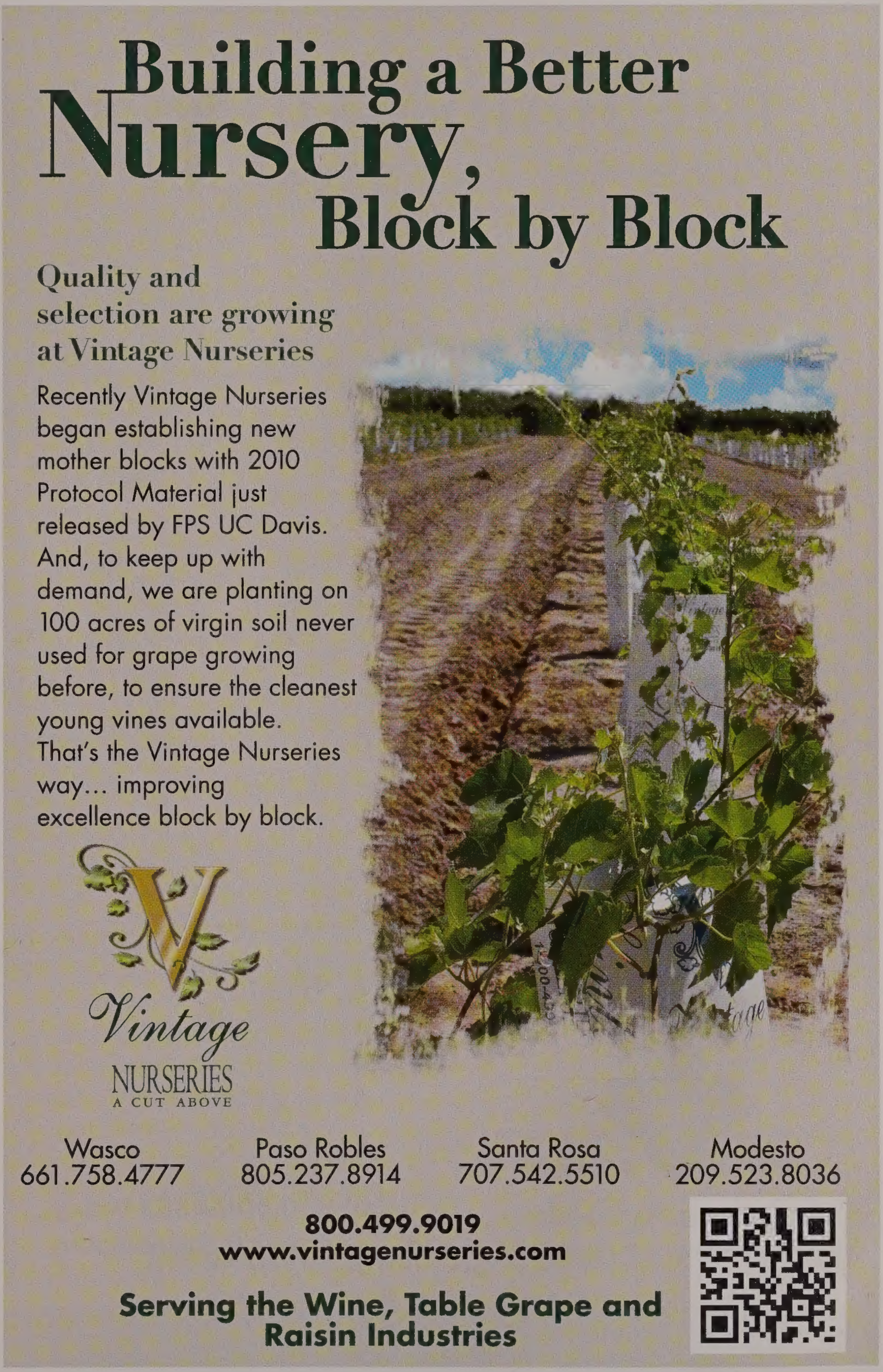


Figure 1. Percent leaf area diseased on Chardonnay leaves receiving (a) full solar radiation, on the outer canopy edge of vines away from trees (No Shade); (b) morning shade from an adjacent grouping of pine trees but otherwise exposed to the sun, i.e., leaves on the outer canopy edge of these vines (Trees); (c) shade provided by the vine itself, i.e., located within the center of the canopy of vines away from the trees (Canopy); or (d) both tree and the internal canopy shading (Tree + Canopy).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new infections that might occur after the application. This means that they need fairly frequent re-application, or should be tank-mixed with something that provides good protective (forward) activity in order to allow longer spray intervals.

The superficial growth habit of PM fungi also makes them uniquely vulnerable to the harmful ultraviolet (UV) rays of the sun, as detailed below.

Effect of sunlight exposure

"It has long been known" that PM is most severe in shaded regions of the vineyard (canopy centers, near trees, etc.), but until recently there was very little work done to determine either the magnitude or cause(s) of this effect. However, Cornell graduate student Craig Austin recently completed a thorough study of the phenomenon, and the results were quite striking.

One of his first experiments was conducted in a New York Chardonnay vineyard where a small portion of the easternmost row was bordered by a group of 50-foot-tall pine trees. The trees completely shaded these vines each day until the sun crested over their tops just before noon. Craig Austin inoculated leaves on either the a) outer, exposed or b) inner, shaded portions of two groups of vines, which were located either (i) immediately next to or (ii) 200 feet away from the trees, thereby providing a total of four levels of natural shade.

The resulting disease severity increased substantially with each increasing level of shade, becoming 8 to 40 times more severe on the most heavily shaded leaves (interior of vines next to the trees) compared to unshaded leaves on the exterior of vines away from the trees (Figure 1).

Although shading could potentially change air temperature or relative humidity within the vine canopy, our measurements did not show this. However, they did show that UV radiation levels and leaf temperatures were dramatically different among the different treatments.

Within the shaded regions, UV levels were (as one would expect) a mere fraction of those in the sun, and temperatures of leaves in the sun were anywhere from 2° to 23°F higher than those of leaves in the shade (the average was around 10°F higher). As we later found out, both elevated leaf temperature and UV radiation are responsible for the inhibitory effects of sunlight on PM development.

Sunlight characteristics influencing powdery mildew development

UV radiation from the sun can damage the cellular structure of virtually all forms of life. However, as noted above, powdery mildew is uniquely vulnerable to such damage due to its superficial growth habit. Additionally, the PM fungus is white

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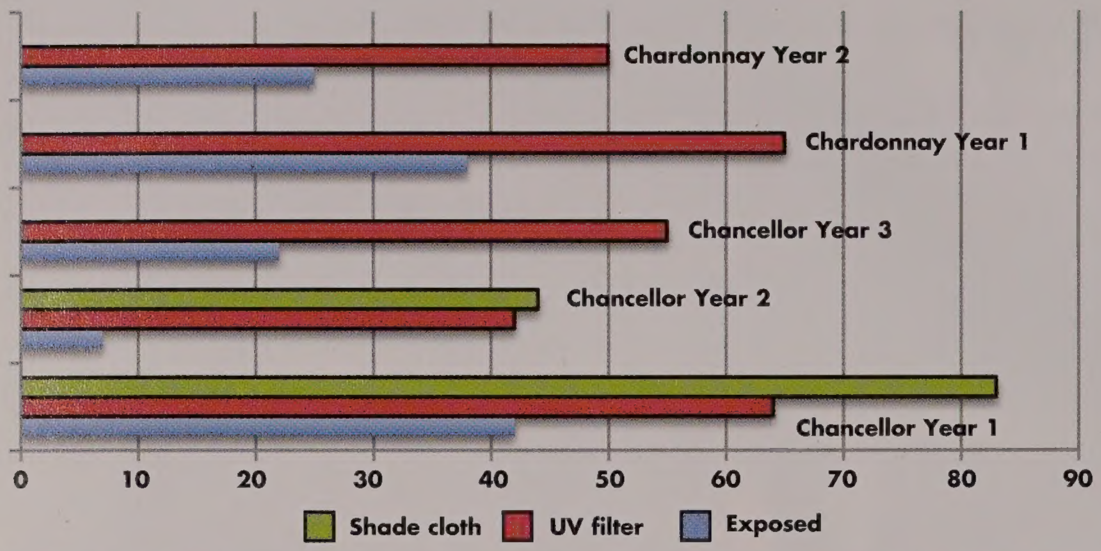

Figure 2. Percent cluster area diseased on cv. Chancellor and cv. Chardonnay vines receiving: full solar radiation (Exposed), sunlight from which 95% of the UV radiation had been filtered (UV Filter), or sunlight reduced to 20% of ambient via neutral density shade cloths suspended over vines (Shade Cloth).

— it has no pigment ("suntan") to protect against the radiation that it is exposed to.

Furthermore, the additional heat of sunlight-exposed leaves and berries lead to suppression or even death of PM colonies on those tissues while colonies on cooler tissues in the shade thrive. Recall that mildew grows best at temperatures around 80°F, but stops growing at temperatures above 90°F and will start to die at temperatures above 95°F, depending on how hot it is and for how long.

On a hypothetical day (or portion thereof) above 80°F, temperatures of shaded leaves and clusters will remain near that of the air — i.e., at or near optimal for PM development. However, nearby tissues that are exposed to sunlight can often have temperatures elevated to a point that is detrimental or even lethal to the fungus.

The effects of UV and elevated temperatures are synergistic (2 + 2 = 6). Example: Riesling seedlings were inoculated with PM spores, maintained at 68°, 77°, or 86°F, and subjected to outdoor levels of UV for 6 hours/day x 4 days. At both 68° and 77°F, the latent period or generation time (i.e., time between inoculation and formation of a mildew colony producing new spores) increased by two days relative to other seedlings at the same temperature that did not receive the UV. However, at 86°F (near the upper threshold for mildew development), UV exposure increased it by seven days.

Surface temperature and UV field experiments

In order to separate these two specific sunlight components, we suspended a Plexiglas "roof" over both Chancellor (highly susceptible interspecific hybrid) and Chardonnay vines in Geneva, NY. Plexiglas blocks UV radiation but permits passage of the sunlight wavelengths that elevate surface temperature. At the Chancellor vineyard, we also suspended shade cloth over other vines to shield them not only from UV radiation but also from the heating effect of direct sunlight.

Clusters were inoculated with PM spores at 75% capfall. As shown in Figure 2, we found that removing UV radiation (Plexiglas filter) increased disease severity on fruit by 50% to fivefold, for both varieties. The Chancellor shade cloth treatment, which eliminated both the increase in surface temperature and UV radiation, further increased disease severity in one of the two experiments.

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Sunlight manipulation in the vineyard

Given that UV radiation and sun exposure reduce PM, how can we use this information to better manage the disease? We examined this question in a young Chardonnay vineyard in Geneva, NY by comparing two training systems, Vertical Shoot Positioning (VSP) and Umbrella-Kniffen (UK), and removing basal leaves around clusters to provide different levels of light exposure in the fruiting zone.

UK-trained vines provided more shoots per linear foot of vine row than VSP, hence more potential for canopy shading in the fruit zone. Within each training system, basal leaves were removed on two dates: two weeks post-bloom (fruit set) and five weeks post-bloom. We inoculated clusters with PM spores at bloom and rated disease severity in each treatment.

We found that both factors affected PM severity (Figure 3). First, powdery mildew severity was lower in the VSP than in the UK training system, regardless of leaf pulling treatment. Second, leaf removal at fruit set significantly reduced the amount of disease in both training systems, but leaf removal five weeks after bloom had no effect.

The benefits of the early (versus late) leaf removal once again illustrate the critical nature of those first few weeks following the start of bloom. This is when the fungus either does or does not get established on the clusters, and you want to hit it not only with your best spray materials but also with the cultural control tools you have available.

The bottom line is that simply by utilizing a VSP training system and basal leaf removal at fruit set, fruit disease severity was reduced by 35% relative to UK-trained vines with no leaf removal.

Exposure of fruit to sunlight and pesticides

Canopy management practices that increase sunlight penetration into the fruiting zone obviously should increase the penetration of sprays

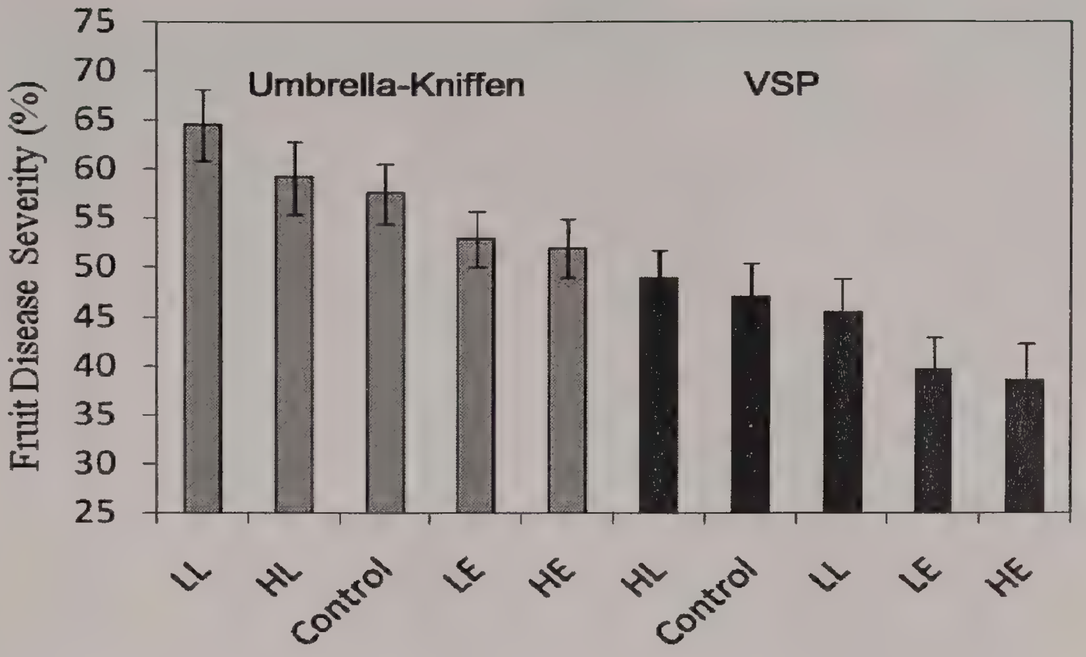

Figure 3. Powdery mildew severity on Chardonnay clusters subjected to five different leaf-removal treatments in each of two vine-training systems. Leaf-removal code: First letter is leaf removal severity, H = heavy, L = light (either two leaves or one leaf above and below each cluster, respectively). Second letter is leaf removal timing, E = early, L = late (two and five weeks post-bloom, respectively). Each data bar represents the mean for 30 clusters per treatment.

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Table I: Control of powdery mildew on Chardonnay grapes, Geneva, NY, 2010.

Treatment, Rate/A*	Leaf Infection		Cluster infection	
	% Leaves	% Leaf Area	% Clusters	% Cluster Area
None	100	70.2	100	99.5
Rally, 5 oz	100	33.2	100	96.7
Revus Top, 7 fl oz	64	1.7	27	3.2
Inspire Super, 16 fl oz	67	2.1	16	2.0
Inspire Super, 20 fl oz**	39	1.1	6	0.2
Vivando, 10 fl oz	12	0.3	12	0.4
Vivando, 15 fl oz	6	0.1	0	0.0
Vangard, 7 oz	100	27.4	100	91.4

* Seven sprays applied at 14-day intervals.

** Contains same dose of difenoconazole as Revus Top treatment + same cyprodinil dose as 7 oz/A of Vangard.

applied to the clusters as well. With the assistance of Dr. Andrew Landers, we were able to quantify the effect that Chardonnay canopy density can have on spray coverage with a Berthoud air blast sprayer delivering 50 gpa shortly after fruit set. The bottom line is that when the average number of leaf layers between the cluster and the sprayer was increased from 0.5 to 1.5, the amount of spray deposited on the clusters was reduced by 50%.

"Cold shock"

Cornell graduate student Michelle Moyer (now Extension Viticulturist at Washington State University), working in the lab of Dr. David Gadoury and Dr. Bob Seem, recently completed her thesis research examining some other aspects of powdery mildew biology. One interesting finding was that cold nights (below 40°F) set PM back significantly.

After as little as two hours at 36°F, portions of existing colonies are killed, and new colonies that do form take longer to develop and are reduced in size. Thus, cold nights during the period between early shoot growth and bloom have the potential to restrict the ability of the PM fungus to produce new spores capable of infecting young, highly susceptible berries.

Or seen another way, lack of such nights — typical in many regions during certain Spring seasons — can give the disease a running start rela-

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tive to a “normal” year. Note especially that prolonged cloudy conditions that otherwise favor PM by increasing humidity and limiting exposure to direct sunlight also limit those really chilly spring evenings that can suppress mildew. Control programs might need to be adjusted should such conditions occur.

Fungicides: an update

1. New(er) products

a. The difenoconazoles — Difenoconazole (DFZ) is an important “new” (to the U.S.) sterol demethylation inhibitor (DMI) fungicide, registered for use on grapes under three different trade names. This apparent confusion is because DFZ is labeled on grapes only in mixtures pre-packaged with another fungicide in the parent company’s product line.

Each mixture has a different name, depending on the “partner” fungicide employed: Revus Top, which also includes a downy mildew-specific material and is the cheapest of the three by far in the eastern region; Inspire Super, which at its top rate of 20 fl oz per acre also provides the active ingredient in Vangard, at a dose equivalent to 7 oz per acre of that material; and Quadris Top, which at its top rate of 14 fl oz per acre also provides the active ingredient from Abound at a rate of 11 fl oz per acre of that product. Not surprisingly, these three DFZ products have different attributes and per-acre costs.

In the eight trials where we have looked at it (two trials each in the past four growing seasons), **DFZ has provided excellent to outstanding powdery mildew control, far superior to that provided by traditional DMI materials such as Rally, Vintage/Rubigan, Procure, and Elite/tebuconazole generics.**

As most growers are aware, performance of the standard DMI products has been “slipping” in a number of locations over the years, throughout the world. For example, in a 2010 Chardonnay trial in New York, a seasonal program applying Rally at its maximum label rate of 5 oz per acre provided virtually ZERO control of the disease on clusters, i.e., they were completely destroyed by mildew. In stark contrast, two different DFZ products (Revus Top, Inspire Super) provided almost complete control (Table I).

Why? As noted in an accompanying text (page 15), resistance to the DMI fungicides is a “shades of gray” phenomenon, dependent on the rate and activity of the material being used. Lab studies show that the dose of myclobutanil (the active ingredient in Rally) required to provide a given level of control of the mildew fungus is many times greater than the dose of DFZ necessary to give the same control, yet they are used at comparable rates of active ingredient in the field.

In other words, against this specific disease, applying the label rate of a

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DFZ product is like putting on many times the label rate of Rally. Each fungal colony is different, but on average, it takes about 40 units of Rally to provide the same level of fungal inhibition as one unit of DFZ, which is why these latter products work better when both are used at comparable rates.

b. Vivando is a new product that received its first EPA registration in 2011. It is a fungicide that controls powdery mildew only, but has shown outstanding activity against this disease in our trials.

For example, it provided 100% control on Chardonnay clusters subjected to extreme disease pressure: high carryover inoculum from the year before, no sprays whatsoever before bloom, untreated vines and those with various ineffective treatments scattered elsewhere throughout the block, 14-day spray intervals (Table I). Vivando represents a new class of chemistry, so there are no cross-resistance issues and it should be a very useful "big gun" addition to rotational programs with other materials.

c. Luna Experience is a new product that received EPA registration in February 2012. Like many new fungicide products, it is a combination of two active ingredients. The one that counts is fluopyram, a new "Group 7" material in the same class as boscalid (the non-strobie component of Pristine). It has shown excellent activity against both powdery mildew and Botrytis in several trials that we have run, which is consistent with results I have seen from a number of other locations. (The second component of Luna Experience is tebuconazole, the DMI active ingredient in the former product, Elite. Unfortunately, formulation of this new product is such that the lowest labeled rate provides just a fraction of the tebuconazole that Elite once did, and it is unlikely to be of much benefit, especially in vineyards with any significant history of DMI use). **CAUTION: At press time, fluopyram had not been approved for any wines exported to Japan.**

Like virtually all new fungicides, the Group 7 materials are at risk of resistance development and must be rotated with other classes of chemistry in order to keep from burning them out. Remember, Luna Experience and Pristine both contain one of these materials, so should not be considered rotational products for one another.

2. Sulfur – We do not use dusting sulfur (too much rain), but sprayable formulations are very popular. A few years ago, we conducted numerous experiments with sprayable sulfurs to get a better handle on various aspects of their activity. A few highlights:

- Sulfur provides very good protective activity on sprayed tissues, but

Continued on page 90

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Overcoming fungicide resistance

BY Wayne Wilcox, Cornell University, Geneva, NY

A number of fungicides that were once highly active have lost their efficacy against specific pathogens in certain regions of the U.S. as the result of a pathogen developing resistance to them. It is extremely likely that this phenomenon will continue to increase in importance in the future, as modern fungicides are almost always more prone to resistance development than traditional, multi-site contact products.

Simply put, the biochemical, single-site specificity of most newer materials that limits their effects on non-target organisms (a virtual prerequisite for registration by government regulatory agencies) also makes it far more possible that fungal individuals will arise that are still able to function with a single modified enzyme that is no longer affected by that material. That is, they become insensitive or resistant to it. Thus, recognizing and implementing effective resistance management strategies has become a requirement for the sustainable use of modern fungicides.

Within an agricultural context, fungicide resistance is a classic example of evolution, i.e., it is the result of the selection of specific individuals from within the entire pathogen population that are best able to survive and reproduce when exposed to that material. When such individuals reproduce preferentially and their proportion of the population increases to the point that the material no longer provides an acceptable level of disease control when it is applied according to label directions, a condition termed “practical resistance” is reached. The risk of this occurring is a function of both the fungicide itself (the biochemical basis of the resistance response) and the individual disease involved.

Diseases at greatest risk are those caused by pathogens with the potential for multiple generations per year (short incubation and latent period), producing large number of spores that can be widely dispersed; powdery mildew is a prime example. In contrast, diseases at least risk are those with a limited number of annual disease cycles, caused by pathogens with limited potential for movement; phomopsis cane and leaf spot is a prime example, having but one disease cycle (fungal generation) per year and spores that are distributed only short distances by splashing rain.

Preveraison symptoms of severe powdery mildew on Chardonnay clusters and shoot.

When resistance to a fungicide is qualitative, individuals within the population are either sensitive to the typical range of doses encountered in the field or are virtually immune to even 100 or 1,000 times these levels. Shifts in the makeup of the population can occur quickly (“disruptive” shift), with the resistant phenotypes becoming predominant within just a few years and control failures occurring suddenly.

A note about terminology: “dose” is related to but not synonymous with “rate.” Rate refers to the amount of pesticide that is applied, whereas dose is the quantity that the fungus actually encounters and responds to.

For example, two different growers can apply the same rate (ounces/acre) of a fungicide, yet mildew individuals in the two vineyards could be subjected to significantly different doses of it as a result of significant differences in spray deposit efficiency and/or canopy volume -- specifically, the total leaf and fruit area across which the spray is distributed.

Continued on page 92

Resistance to fungicides in California populations of *Erysiphe necator*

BY Doug Gubler, Plant Pathology Dept., UC Davis

In 1982, triadimefon was introduced into California to control powdery mildew in vineyards. In 1985, grape growers in California started to see efficacy problems in their powdery mildew control programs. By 1986 powdery mildew was in epidemic level all over the state.

We tested isolates and found that, in the 1986 population, there were very high frequencies of reduced sensitivity to triadimefon. However, in 1987 the product worked well. This created obvious confusion

Research in the next four years showed that there was resistance in nearly all California production regions, but that the degree of resistance was not the same in all regions. For example, in the Central Coast region there were high levels of resistance with some isolates able to attack after a 4-oz application in only six hours after the application. In the Central Valley, reduced sensitivity was documented but most isolates were still considered to be close to wild type isolates in regards to their ec50 values.

Why did the product work in 1987? In comparing weather data for 1986 and 1987, the two years were completely different. The 1986 growing season started with rain (we had just documented that ascospores functioned in the disease cycle and their release from fruiting bodies required rainfall to initiate disease), and temperatures were moderate for long durations of time. This allowed rapid population buildup. The more resistant members of the population were not killed by a triadimefon application thus allowing them to continue to reproduce while the sensitive members of the population were killed by the application.

After only two applications we found that the resistant population quickly became the primary population. This then resulted in nearly complete efficacy loss. In 1987, the weather was hot with no spring rainfall and the population began to die out simply due to heat. Since the reproductive rate during high temperatures was approximately a two-week minimum, the population was a mixture of resistance in various degrees.

We showed that, under conditions of high temperatures (above 92°F), the wild type isolates and the resistant isolates were killed equally well with a 4-oz application of triadimefon. Therefore the explanation of why no control in 1986 and virtually 100% control in 1987 was that temperature masked the presence of resistance in 1987.

Since these early findings we have seen more examples of both 1986 and 1987 growing seasons. Growers have been able to continue to use DMI fungicides in California because we were able to document that the resistance was primarily due to high usage rates (selection pressure) between 1982 and 1986 along with poor application (coverage), reduced concentrations, and the presence of sexual reproduction in the pathogen which allowed for genetic recombination.

In the years since finding DMI resistance, many more products have been introduced for powdery mildew control. Growers and Pest Control Advisors have done a superior job in managing fungicide resistance and preventing further resistance to DMI and Strobilurin fungicides.

More efforts have gone into educating growers so they do not overuse a specific type of chemistry in a given year. More attention is being paid to coverage and product concentration. We learned our lesson well in dealing with DMI resistance, and this has carried over to protection of all fungicides in recent years. We have not observed resistance to Quinoxifen or the Strobilurin fungicides and much of this is because growers continue to alternate or tank mix chemistries for disease control.

Resistance in *Botrytis cinerea*, the cause of Bunch rot -- We recently have documented resistance to the SDHI fungicides in *Botrytis cinerea*. Resistance to Boscalid was observed in our fungicide trials in 2010 and 2011 in the Carneros region and was confirmed in San Benito County. This is an interesting phenomenon because Pristine has been used more for powdery mildew control in these sites.

This appears to be a classic case of resistance development in a non-target organism. Pristine used against powdery mildew required a lower rate than use requirement for *Botrytis cinerea*. Therefore, applications used for powdery mildew resulted in increased selection pressure on the Botrytis population and probably resulted in formation of resistance to Botrytis.

In 2011, we were able to show that Pristine was still effective but to a lesser degree in controlling Botrytis. Pristine is still effective for powdery mildew and botrytis control, but should utilize the highest use rate for botrytis control. ■

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Horticultural oil is a cost-effective tool for an IPM program dealing with powdery mildew, mites, and leafhoppers at Robert Young Vineyards (Alexander Valley, Sonoma County, CA). The ability to eradicate mildew makes it a good choice when outbreaks occur. The non-specific mode of action means resistance is very unlikely to develop, whereas using more standard fungicides, such as DMIs or Strobilurins, with single-site mode of action on active mildew infestations can promote resistance.

APPLICATION OF HORTICULTURAL OIL

Two-year comparison of ripening parameters on treated/untreated Chardonnay grapes

BY Laura Breyer,
Breyer's Vineyard IPM Service; IPM Field Specialist (Sonoma County Winegrape Commission)

Applying horticultural oil to help control powdery mildew and suppress grape leafhoppers, mites, scales, and mealybugs is becoming a more widely practiced integrated pest management (IPM) strategy due to oil's suppressive influence on insect and mite populations, oil's ability to eradicate mildew, the low probability of resistance developing to oil, damaging populations of mites and leafhoppers related to sulfur application, and concerns over sulfur dust's role as a particulate air contaminant.

As with any new practice such as applying horticultural oil on a regular basis during the growing season, there are drawbacks that need to be understood before the program can be utilized to full potential. Oil is a contact material and is generally used in combination with materials of longer residual duration such as the sterol inhibitor (SI) or strobilurin fungicide classes.

Robert Young Vineyards uses a two-row 200-gallon ON Target electrostatic sprayer on 211 acres of Smart-Dyson bilateral cordon vertically separated Chardonnay, Riesling, Melon, Pinot Blanc, Sauvignon Blanc, Viognier, Cabernet Sauvignon, and Merlot vines in Alexander Valley. Spraying two vine rows (six-foot wide tractor rows) at 15 to 30 gallons per acre allows two to three times more acres to be sprayed in one day, operating at a speed of 2 to 3 mph.

Compared to sulfur, this incurs more direct expense for growers in material costs and potentially in application time as sulfur dust is quick to apply, but this is balanced against the 7 to 10 days effectiveness of sulfur dust in comparison to 14 to 21 days effectiveness of SI or strobilurin products. Horticultural oil can damage the canopy in hot weather particularly if alternated at too short (less than 10 days) an interval with sulfur. It affects the waxy bloom on berries, superficially and temporarily altering fruit appearance.

Table I: 2009 trial rates

Date	Total Gallons per acre	Gallons oil per acre
May 29	30	0.29
June 13	30	0.29
June 27	30	0.29
July 11	30	0.29
	Total Oil:	1.2 gal

Of primary concern, though, is the potential of oil to alter fruit ripening parameters and yield. Tony Wolf (Virginia Tech professor), published research, "Effects of Horticultural Oils

Table II: 2010 trial rates

Date	Total Gallons per acre	Gallons oil per acre
June 17	30	0.29
July 3	30	0.29
July 13	30	0.29
July 31	30	0.29
	Total Oil:	1.5 gal

on the Photosynthesis, Fruit Maturity, and Crop Yield of Winegrapes" (2002 *Amer. Jour. of Enology & Viticulture*), in which he found delayed ripening and lower yields with some of the treatments. Total gallonage of oil per acre in the Virginia trial ranged from 3 gallons per acre (gpa) to 30 gpa (1.5% oil in 1,860 L/ha to 18,600 L/ha).

Wolf's results "highlight the potential negative impacts that [horticultural oil] can have on fruit composition and fruitfulness if used excessively. Horticultural oil reduced grapevine photosynthesis rates, transpiration, and stomatal conductance. The response was volume and frequency dependent, with high volumes of oil causing greater decrease in photosynthesis than lower volumes, and with reductions sustained by repeated oil application.

In addition to reducing photosynthesis, horticultural oil delayed the accumulation of soluble solids in fruit. Components of crop yield, including flower clusters per shoot in the subsequent year, were reduced when oil/water was applied at very high volume (such as 30 gallons of oil per acre)." (*Am. J. Enol. & Vitic.* 53:2 2002).

In contrast to 30 gpa, one North Coast California grower using an oil IPM program applies much less during the growing season. The question arises whether oil is delaying ripening or reducing yield for growers in California conditions and employing lower rates than those that caused the most notable issues in the 2002 study.

Jim Cuneo manages the Robert Young Estate Vineyards in Alexander Valley (Sonoma County, CA) and has been relying on horticultural oil as a key component in his IPM program for five years to significantly reduce mite, leafhopper, scale, and mealybug treatments.

2009 Trial Setup

In 2009, Cuneo set up a replicated but non-randomized trial in three blocks of Chardonnay using 1% JMS Stylet-oil plus a mildewcide in the tank-mix compared to the same program without oil in alternating sets of eight vine rows. Three applications of wettable sulfur began the growing season prior to the horticultural oil/mildewcide applications.

Trial treatments were made on four dates between post-bloom and veraison. Table I has the 2009 treatment dates and rates, including the total amount of horticultural oil applied for the season. Mildewcides in the tank-mix included a rotation of Rally, Pristine, Quintec, Rally, and Flint.

2010 Trial setup

In 2010, Cuneo set up a replicated, randomized trial in the largest Chardonnay block from the 2009 trial. There were five sets of eight treated and untreated vine rows (total of 80 vine rows in the trial). The two treatments were: 1% JMS Stylet-oil plus mildewcide or the same mildewcide without oil. Table II shows the 2010 treatment dates and rates, including the total amount of oil applied for the growing season .

2009 and 2010 methods

From veraison to harvest, a berry sample was taken from each set of the treated and untreated of rows (12 total samples per week in 2009, and 10 total samples per week in 2010). Samples were a minimum of 300 berries. Berries per sample were counted, allowing for gram per berry and thus sugar per berry to be calculated along with Brix, pH, and TA. Analyses were conducted at Vinquiry (Windsor, CA).

In 2010, small wine lots were fermented to dryness in used oak barrels for wine sensory analysis. The treatment and control were harvested on the same day, taking a representative number of vines from each plot. Vines were pre-selected based on position in the vine row.

Results and Discussion

Figures 1, 2, 3, 4 show the weekly average of the treated and untreated samples for Brix, TA, pH, and sugar per berry respectively. Harvest was not delayed for the oil-treated vine rows, and these results lend credence to the observation of growers in the North Coast viticultural region who have been applying oil that there is no noticeable impact on ripening when oil is applied in this manner.

In the 2010 trial, the trial winemaking staff was unable to detect any difference between the wines made from grapes treated with and without horticultural oil in blind triangle tastings.

Alexander Valley Chardonnay is harvested relatively early (mid-September) and there are adequate heat units and sunlight to ensure this every year. In other areas or other varieties or different oil programs* more noticeable differences could be possible. Vinification of the 2010 trial and subsequent blind tasting by an experienced panel showed no difference in the wines made from grapes treated or not with JMS Stylet-oil. It would be interesting to compare

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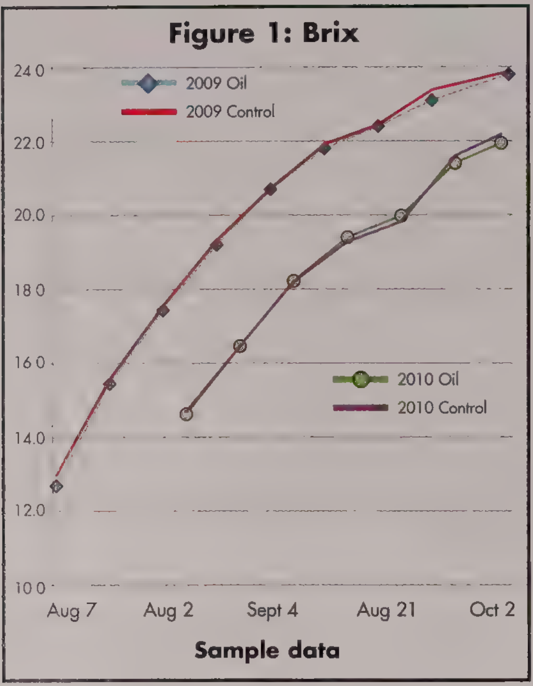

Figure 1: Brix

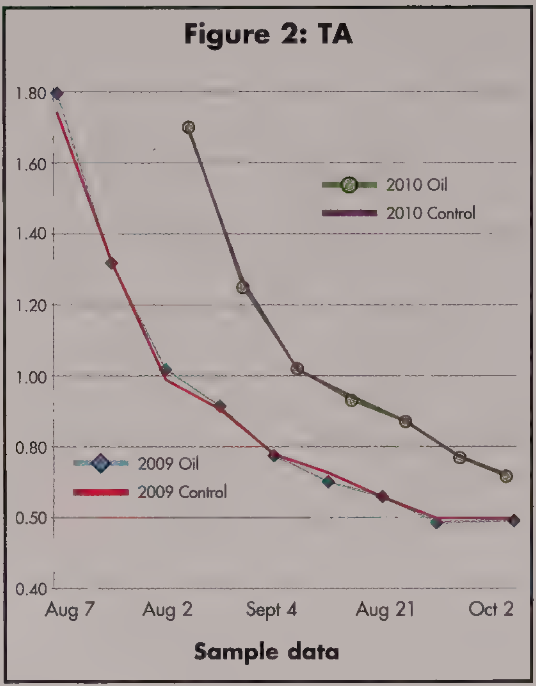

Figure 2: TA

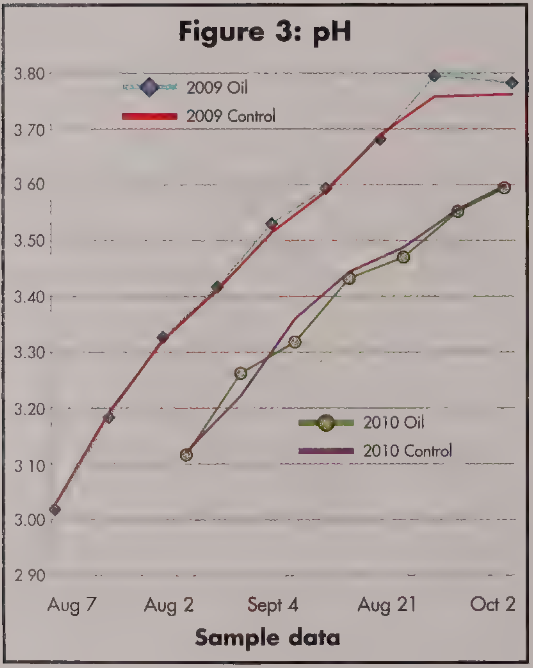

Figure 3: pH

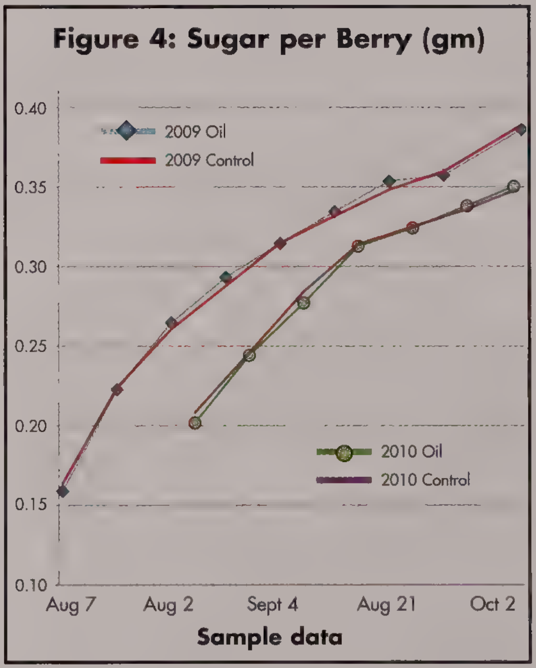

Figure 4: Sugar per Berry (gm)

wine made from grapes treated with horticulturaloil that had experienced a longer "hang time" to reach the same Brix as untreated grapes since it is not a foregone conclusion that an extended ripening time would be a negative wine quality impact.

Cuneo estimates a 90% reduction in insecticide and miticide treatments since integrating horticultural oil into his mildew prevention program. With this benefit to the vineyard ecosystem and a burgeoning pride of sustainable management among growers, it seems worth the effort of learning to work with a model IPM program such as this. The economic component of lower costs from fewer insecticide and miticide treatments also factors into the benefits of this program.

Mark Battany (UC Cooperative Extension Central Coast Farm Advisor), has several years' data examining horticultural oil's affects on ripening and yield, and also includes a summary chart of different researchers' trials showing a relationship between rates and ripening delays. This research can be found in the May 2010 edition of the Grape Notes newsletter in the Viticulture section of the UCCE San Luis Obispo website. ■

ACKNOWLEDGMENTS

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IMPROVEMENT OF PHENOLIC COMPOSITION OF SYRAH

BY **Sean Pinnell,** E&J Gallo Winery
S. Kaan Kurtural, Dept. Viticulture & Enology, Bronco Wine Company Viticulture Reasearch Chair, California State University, Fresno

Compounds other than water, sugars, acids, and minerals account for only a small proportion of the grape harvest, but contribute significantly to fruit and perceived wine quality.[2] Of these, phenolic compounds are some of the most important.

All phenolic compounds are comprised of an aromatic ring consisting of six carbon atoms with one or more hydroxyl groups or some derivative of this structure. Phenolic compounds are important for the color and astringency of red wine, contribute to grape and wine flavor and aroma, and are the main substrates for juice and wine oxidation.[2]

The anthocyanin, flavonol, and tannin profile of harvested fruit determines the color potential of a wine, and color is the main driver of perceived quality in red wines.

While the phenolic content of a wine reflects the vinification process to a certain point, the primary determinant is the composition of grape berries at harvest.[1] Therefore, considerable research efforts have been directed toward understanding the nature of phenolics in grapevines, factors influencing their biosynthesis, and how a grower might use this knowledge to manipulate the phenolic composition of berries by harvest.

Phenolics are produced inside the berry and are classified into non-flavonoids that accumulate mainly in the pulp and flavonoids that accumulate in the skin, seeds, and stems.

Three classes of flavonoids are commonly detected in grapes and wine: anthocyanins (responsible for color in grapes and red wine), flavonols (act as UV protectants and free-radical scavengers, and contribute to wine color via co-pigmentation), and tannins (important component of gustatory impact contributing to body and mouthfeel).

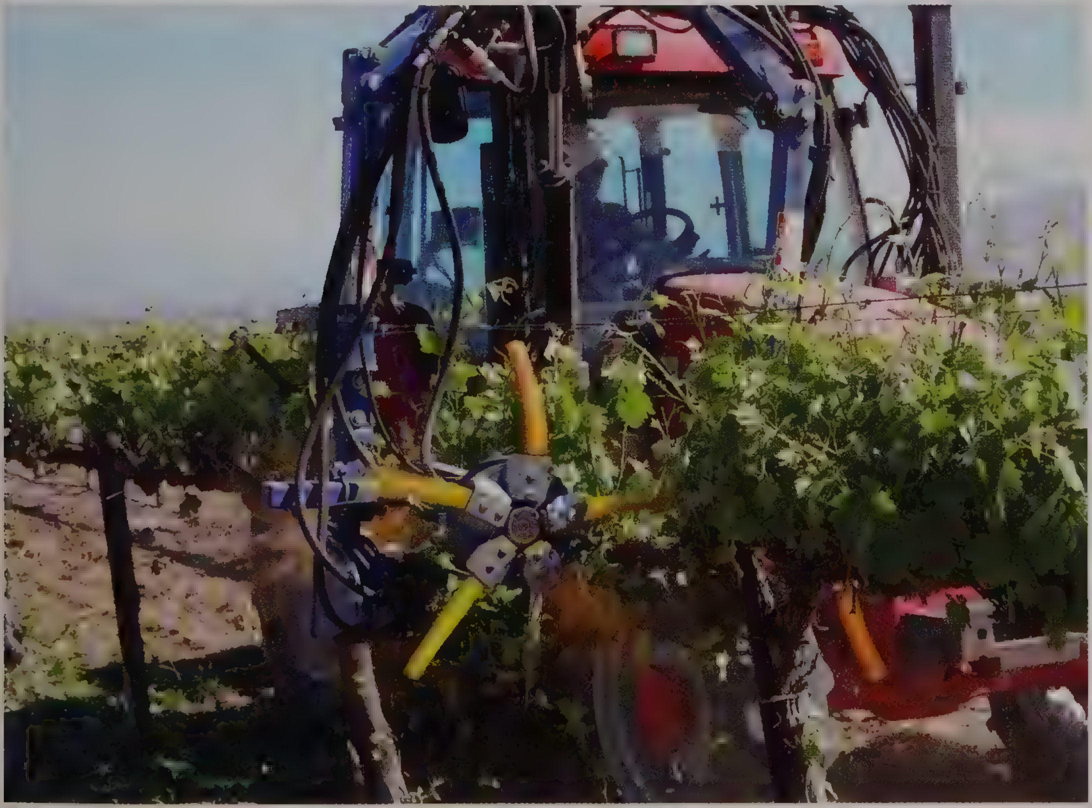


Figure 1. Mechanical shoot thinning in the vineyard.

Canopy and cropload management

Vineyards in the San Joaquin Valley (SJV) of California are benefiting from increased availability of and improvements in mechanized canopy management options, combined with phenologically-timed regulated deficit irrigation (RDI). Even though ample yield per acre in the SJV is still paramount, there is no question that growers are also benefiting from quality improvement.

The size of vineyards in San Joaquin Valley more often than not results in harvested grapes not being segregated into individual lots at the wineries.

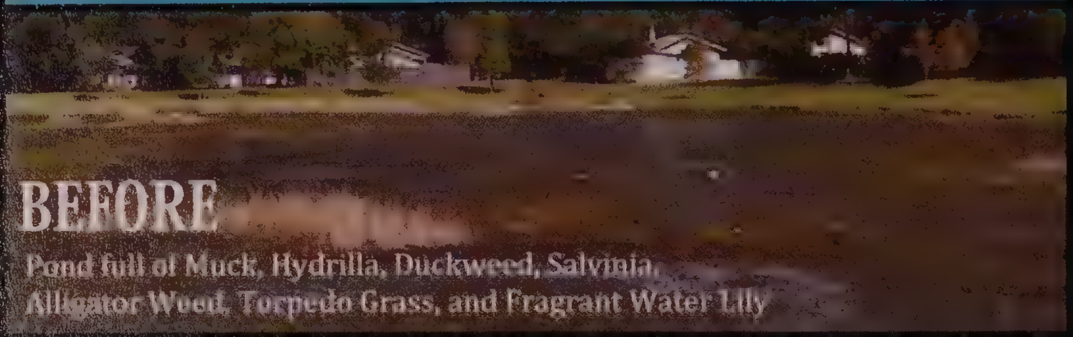
Using mechanized methods to manipulate the canopy would ensure that growers can generate canopies of specific architecture that would optimize light and temperature microclimate in the fruit zone. This would enable the growers to achieve optimum crop load, thus more sustainable yields with greater berry anthocyanins, tannins, and flavonols from large-acreage vineyards in the SJV.

Recent literature indicates that mechanically box-pruning vines to a four-inch hedge, then shoot thinning to a density of seven count shoots per foot of row provides ample exposed shoots per acre, about four leaf layers in the fruiting zone and 11 tons per acre yield, with a crop load of ten pounds of yield per one pound of dormant pruning weight.[5] This is important for SJV vineyards, in which mechanization can be used to repeatedly produce canopies of specific architecture traditionally attained only by costly hand-pruning and manual canopy manipulation.

Irrigation management

There is potential in the San Joaquin Valley for fruit and wine quality

Do you have a pond with algae or too much muck?



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improvement using RDI. Cutting back on irrigation undoubtedly reduces costs associated with overgrown canopies and pest and disease control, and facilitates harvest. Reduction in irrigation has actually increased yields in the SJV.

Research conducted at UC Kearney Agriculture Center has demonstrated that grape yields are maximized at a fraction of full evapotranspiration. Over-irrigated vineyards are usually characterized by dense foliage and excessive shading in the fruit zone.

A dense and shaded fruiting zone also tends to shade the latent buds that would carry the next season's crop. This shading reduces the fruitfulness of the buds, resulting in high and low yield in alternating years.

Recent literature indicates that using physiological thresholds such as mid-day leaf water potential during key phenological stages can improve fruit composition at the farm gate.[4] Combining physiological threshold-based RDI scheduling and mechanically managed canopies of a desired architecture has improved berry phenolic composition of Syrah grapevines in San Joaquin Valley.[6]

The authors combined mechanical box pruning and shoot thinning to expose approximately 70,000 shoots per hectare while spacing the shoots about two inches apart on the cordon, exposing 13 m^2 of leaf area.

In addition when RDI was scheduled to be applied at a mid-day leaf water potential of -14 bars between fruit set and veraison, the combination of mechanized canopy management and RDI scheduling resulted in improved berry phenolic composition without adversely affecting yield.

Using these management practices, the authors achieved the goal of attaining optimum crop load of 10 lbs and a leaf area to fruit ratio of 0.75 m^2/kg consistently over two years. In the resultant crop, the berries were smaller in size compared to the hand-pruned, and irrigated to a threshold of -12 bars mid-day leaf water potential between fruit set and harvest, but had higher total phenolics and anthocyanins with almost twice the yield per acre.

However, the precise role of mechanization in canopy manipulation, in addition to water restriction at key phenological stages would be better understood if their collective influence on wine phenolic composition is examined.

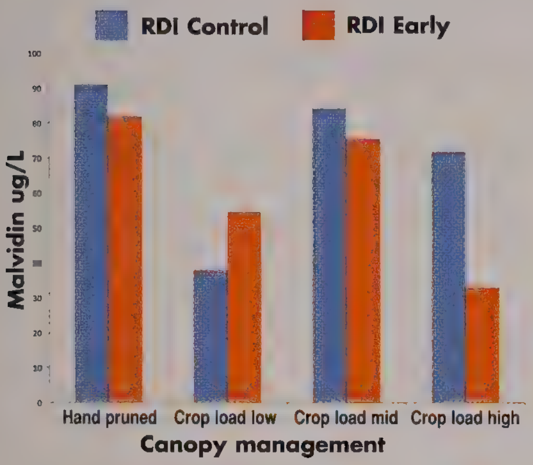

Figure 2.a. Interaction of mechanical canopy management and regulated deficit irrigation on malvidin concentration of Syrah wines.

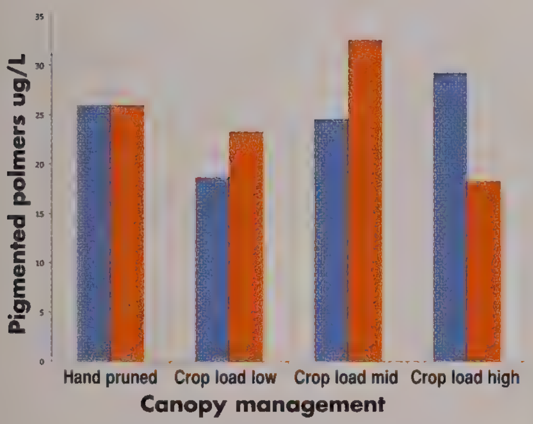

Figure 2.b. Interaction of mechanical canopy management and regulated deficit irrigation on pigmented polymer concentration of Syrah wines.

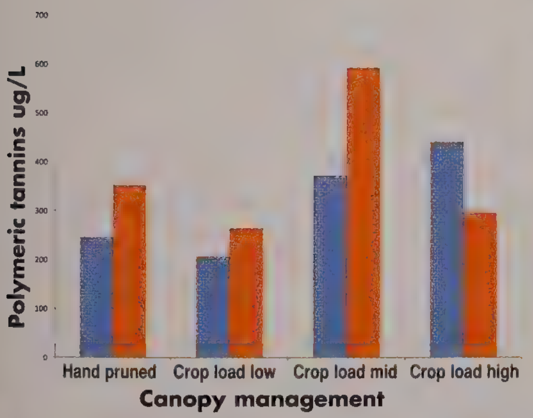

Figure 2.c. Interaction of mechanical canopy management and regulated deficit irrigation on polymeric tannin concentration of Syrah wines.

Experimental set-up

In an effort to better understand the collective influence of mechanical canopy manipulation and irrigation restriction at key phenological stages, an experiment was initiated in 2010 in Merced County (California) in a commercial Syrah vineyard planted with 1103-P rootstock. The grapevines (spaced 7 feet by 11 feet) are trained to a bilateral cordon at five feet above ground with two foliage support wires at 5 feet, 8 inches above ground, with a 10-inch wide t-top. The vineyard is drip-irrigated with pressure-compensating emitters spaced every 38 inches (two emitters per vine).

The experiment was a four (canopy management) x two (RDI) factorial. Three mechanized canopy management treatments were initially machine box-pruned to a four-inch hedge, using a 24-inch double; sprawl-pruner head (model 63700, Oxbo Int. Inc., Kingsburg, CA) mounted onto an Oxbo 1210 single-row, tractor-mounted tool carrier. A control section was hand-pruned to 22 spurs per vine with two buds.

All mechanized shoot thinning treatments were applied when shoots were about eight to ten inches long with a rotary-paddle shoot thinner with a rotary brush attachment (model 62731, Oxbo Int. Inc.).

The crop load low (CLL) and crop load middle treatments (CLM) were applied by mechanically shoot thinning to a target of five count shoots and to a target of seven count shoots per foot of vine row, respectively. The crop load high (CLH) treatment received no shoot thinning.

Every 14 days during the growing season, shoots of all treatments were vertically positioned in a downward direction to reduce intra-vine shading. No skirting of the canopy or leaf removal was conducted in the fruit zone in 2010 or 2011.

Two regulated deficit irrigation (RDI) levels were applied as splits

Birds cost US growers millions of dollars annually in lost and damaged fruit.

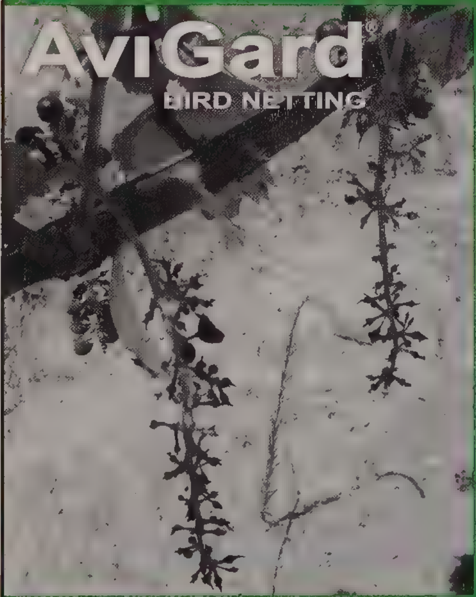

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Table I. Effect of mechanical canopy management and regulated deficit irrigation on wine physical properties

	A520	% Alcohol	K+	pH	TA
Hand-pruned	2.21	13.32	1257	3.88	5.65
Crop load low	1.73	13.22	1252	3.86	6.41
Crop load mid	2.36	13.34	1331	3.94	5.50
Crop load high	1.92	13.53	1281	3.90	5.98
Pr>F	0.0001	0.1165	0.0078	0.0007	0.1574
RDI control	2.32	13.28	1255	3.88	5.73
RDI early	2.63	13.42	1306	3.91	6.04
Pr>F	0.0127	0.1314	0.0041	0.0154	0.3015
Interaction	0.0001	0.0001	0.0320	0.0001	0.3721

within each main plot by imposing different irrigation practices to the respective drip line. Rainfall in winter and spring was insufficient to fill the soil profile.

The root zone was irrigated beginning in the third week of April based on a crop coefficient (Kc) of 0.2 and 80% of reference crop (grass) evapotranspiration (ET_O) obtained from a CIMIS station (Merced, CA). Irrigation was interrupted before bloom, and the soil was allowed to dry down until mid-day leaf water potential (leaf Ψ) was < -10 bars to control shoot growth.

After fruit set, RDI treatments were imposed. The ET_O and a Kc (starting at 0.3 at fruit set to 0.7 at veraison and 0.5 post-harvest), developed for fully irrigated grapevines in San Joaquin Valley was used to calculate irrigation amounts based on vine water status.[7]

A commercial control RDI (RDIC) treatment (70% of daily ET_O) was applied when leaf Ψ was below -12 bars starting at fruit set. An early RDI stress treatment from fruit set to veraison (RDIE) was applied to replace 50% of ET_O when leaf Ψ was below -14 bars during this period, but not thereafter.

Winemaking

The grapes were harvested by hand when they reached 24° Brix. Fruit from adjacent blocks (1 + 2, 3 + 4) were pooled to provide two fermentation replicates for each treatment at Cottonwood Creek Winery in Madera, CA. The fruit was crushed and destemmed. The must was sulfited at 15 mg/L. The must from each combined treatment replicate was divided into two equal 2,000 gallon open-top fermentors.

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TUESDAY: Building Vineyard Fertility/the Major Nutrients

Sessions: 8-12 & 1-5:30 with breaks.
1) Nitrogen & Sulfur. 2) Compost. 3) P & K Needs. 4) Sodium. 5) Evaluating Excesses.

WEDNESDAY: Vineyard Soils, Grapes & Micronutrient Needs

Sessions: 8-12 & 1-5 with breaks.
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Each treatment replicate was inoculated with 0.2 g/L of commercial yeast (*S. cerevisiae*) Cotes des Blancs. All fermentations were conducted indoors with temperature maintained at 23°C. The cap was submerged twice daily by equal plunging treatments. After achieving dryness the wines were pressed in a screw press to a pressure of 2.0 bars (maintained for 30 minutes).

The wines were inoculated with malolactic bacteria (0.01 g/L) for malolactic fermentation at 23°C under a carbon dioxide atmosphere and completion was confirmed by paper chromatography. All wines were sulfited at 50 mg/L and cold stabilized at -2°C. Replicate 28.4-L samples were drawn for wine composition analysis with high performance liquid chromatography and spectrophotometric methods.

Results and Discussion

The yield components of Syrah vines responded readily to mechanical canopy management and RDI. The berry weight at harvest ranged from a high of 1.72 grams with HP irrigated with RDIC to a low of 1.20 g with CLM irrigated with RDIE. A similar response was repeated in cluster weights that ranged from a high of 170 g with HP+RDIC to a low of 110 g with CLM+RDIE.

However, yield per acre was more dependent on the number of clusters retained with canopy manipulation. The vines that were treated with CLM+RDIE, although having the smallest berries and clusters, yielded 11 tons per acre, compared to HP+RDIC yielding 6.8 tons per acre.

Contrary to popular belief, the low yielding HP+RDIC vines did not optimize berry skin phenolics. A combination of CLM+RDIE resulted in the highest skin phenolics and anthocyanins. Tannins in the berries were mostly unaffected by canopy manipulation or changes in bunch exposure.

There was a strong interaction of mechanical canopy management and RDI when the physical properties of the resultant wines were examined (Table I). The higher anthocyanin accumulation witnessed in the field with CLM+RDIE also translated into higher color in the wine. The combination of CLM+RDIE and HP+RDIE had the highest absorbance values at 520nm, indicating deeper red color. Interesting to note, in the wine's physical properties is the increase in potassium concentration with the CLM+RDIE combination.

Few studies have examined links between viticultural practices and phenolic composition of grapes and wine. There is evidence in the literature on the effect of cluster shading of Pinot Noir, where total phenolics were higher in wines made from exposed clusters compared to shaded clusters.[3]

The study presented herein demonstrates that increased phenolics

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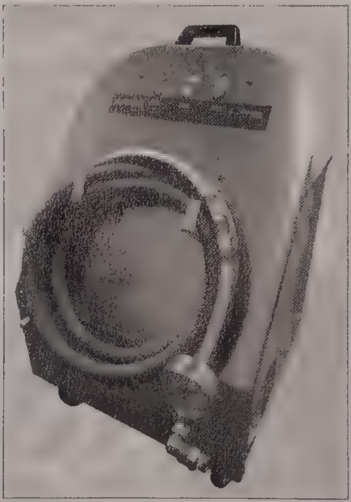

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and anthocyanins at harvest result in higher color in the finished wine. When the phenolic composition of the resultant wine is examined with liquid chromatography, the benefits of combining mechanized canopy management and phenology-based RDI are even more evident.

Anthocyanins are the main class of phenolic compounds responsible for red color in grapes. This class of phenolic compounds in grapes is based on cyanidin, peonidin, delpinidin, petunidin, and malvidin. In warm climate viticulture, malvidin derivatives are mostly responsible for color of the wine, as in the study presented.[5]

The malvidin concentration in Syrah wine was affected by the interaction of mechanized canopy management and RDI in this study (Figure 2a.). The treatment identified with the highest berry skin anthocyanin (CLM+RDIE) still had higher malvidin in the wine. It is interesting to note that the low yielding CLL treatment had one of the lowest malvidin concentrations regardless of irrigation regime. The control treatment had similar malvidin concentration to CLM+RDIE; however, the control treatment was far from achieving an economically sustainable yield for SJV.

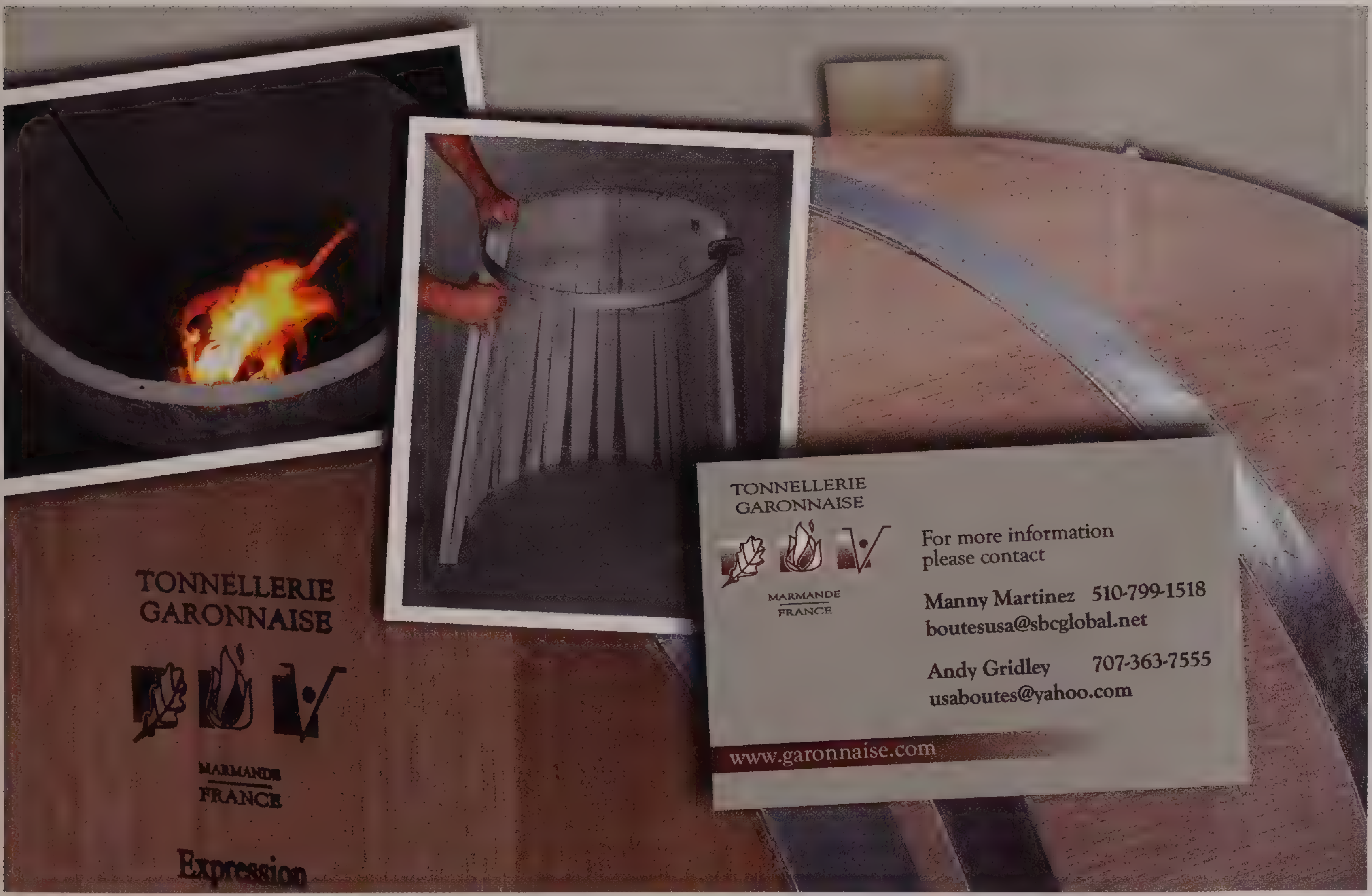
The amount of pigmented polymers in Syrah wine was optimized with the CLM+RDIE treatment (Figure 2b.). The lower yield CLL treatment (when irrigated with RDI control) had one of the lowest pigmented polymers.

Restricting irrigation application between fruit set and veraison also decreased the pigmented polymers for the wine made from vines treated with CLH. Recent literature also points in this direction where wines made from shaded grapes (as in the CLH) had fewer pigmented polymers and proanthocyanidins.[3]

The effects of canopy manipulation on tannin accumulation in the berry and extractability remain an active area of research. There is agreement in the literature that there is no appreciable difference in tannin content of the berry at harvest based on cluster exposure.[1,6] However, we have seen almost a 2x increase in the polymeric tannin content of Syrah wines when managed with the CLM+RDIE treatment, compared to HP+RDIC (Figure 2c.)

The phenolic composition of resultant wines cannot be summarized by the three variables mentioned above. In addition to those three compounds, others interact with each other to constitute the phenolic profile of a wine. When all the measured phenolic compounds were analyzed with principal components analysis the effects of mechanical canopy manipulation and RDI were more evident.

The treatment combination (CLM+RDIE) with the optimal crop load, better berry skin phenolics, and sustainable yield resulted in the optimal quadrant of the wine phe-



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nolic profile (Figure 3). In addition to the CLM and RDIE combination, HP+RDIC; CLL+RDIC; CLH+RDIC, and CLL+RDIE also placed in the right vectors of the Syrah wine profile. Treatments that did not perform as well as CLM+RDIE in the field did not have as well defined wine phenolic profile either.

Assuming most other inputs in the SJV are relatively constant, the influence of mechanical canopy management and RDI can be summarized as affecting light and temperature in the fruiting zone, thereby influencing berry skin phenolics, and the carryover effects are seen in the resultant wine. Long recognized but difficult to prove on a commercial scale was the effect of crop load on wine phenolics.

Literature has identified a sustainable method that can provide optimum crop load in the SJV with sustainable yields.[6] This method, which combines mechanical pruning and managing the canopy in addition to restricting water inputs between fruit set and veraison, also was shown here to optimize the wine phenolic profile.

However, wine is a complex beverage and the effects of this management method on odor activity values, in addition to the phenolic profile, need to be examined further before uniform recommendations can be made. ■

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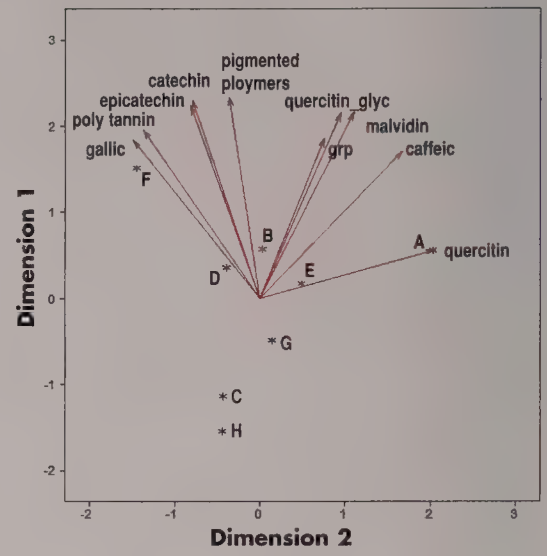
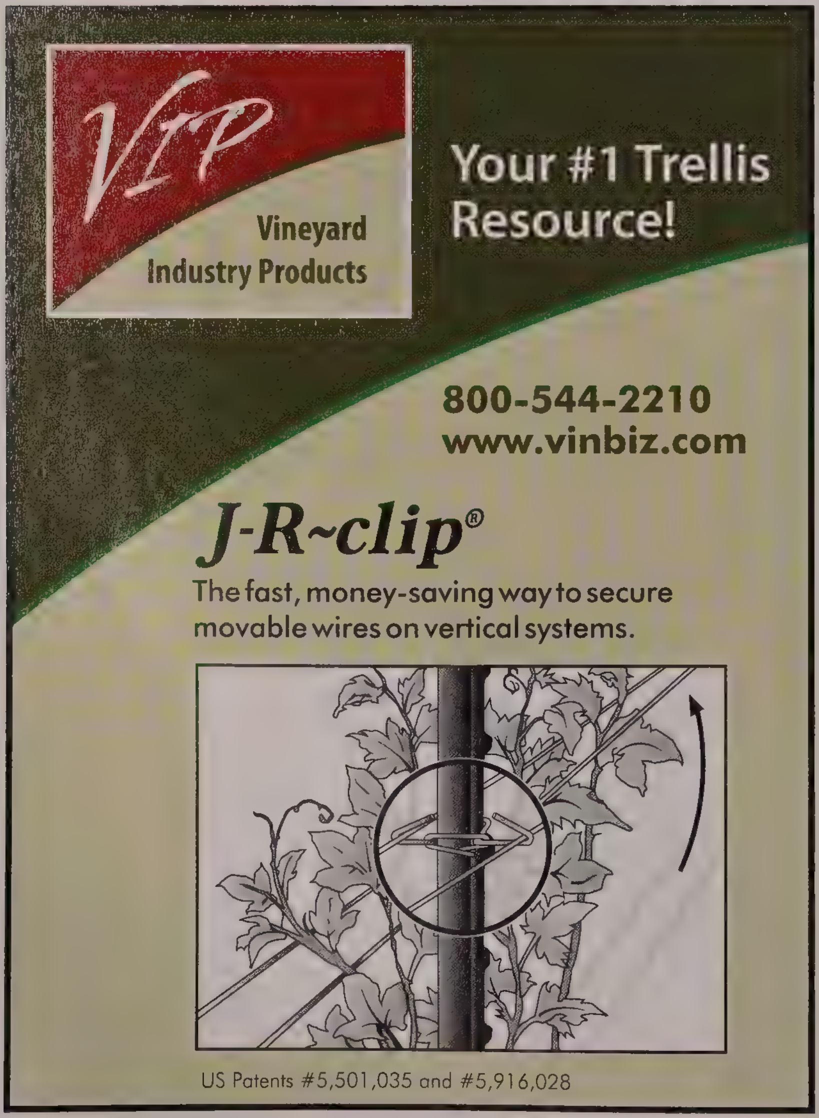


Figure 3. Principal components analysis of Syrah wine phenolics as affected by interaction of mechanical canopy management and regulated deficit irrigation: A: HP+RDIC, B: CLM+RDIC, C: CLL+RDIC, D: CLH+RDIC; E: HP+RDIE, F: CLM+RDIE, G: CLL+RDIE, H: CLH+RDIE.

References on page 46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Courtesy UC Davis

UC Davis seeks $2.8 million for rootstock facility expansion

Intent on enhancing UC Davis' ability to supply disease-free rootstock to California nurseries and better support the state's important grape and wine industries, the campus is seeking industry partners to contribute $2.8 million to help complete construction of a key addition to the Foundation Plant Services complex.

The Foundation Plant Services clean-plant program uses state-of-the-art technology to ensure that producers stay competitive in the global market. Plants that pass through the program are screened for damaging viruses, and checked to make sure they are correctly identified at the varietal level.

A new 7,580-square-foot Trinchero Family Estates Building is designed to meet LEED silver environmental certification, with many sustainable design features, including water and energy efficiency. (LEED, stands for Leadership in Energy and Environmental Design and is a program created by the U.S. Green Building Council.)

In 2009, the Trinchero Family Estates (a family-owned wine company in Napa Valley), gave $1 million toward the building, which will cost a total of $3.8 million to construct.

Construction progress

Construction of the new building has begun adjacent to the existing Foundation Plant Services building on Hopkins Road, west of the UC Davis campus and near the university airport. Targeted to open in 2014, the building will house scientists and their equipment, while providing much-needed space for classes and public meetings.

Construction of the building shell is underway and is slated for completion in May, 2012. Further construction will depend on the success of fundraising efforts for the building.

"FPS is a self-supporting organization established more than 55 years ago in the spirit of partnership, and we are confident that our industry friends will help us ensure that the service remains a vibrant, cutting-edge program," says Deborah Golino, director of Foundation Plant Services.

The primary focus of Foundation Plant Services, which is part of UC Davis' College of Agricultural and Environmental Sciences, is producing the highest quality plant materials that have been virus tested and professionally identified using state-of-the-art technology. It is dedicated to the distribution of plant materials that were either produced by UC researchers, improved by technology developed by UC researchers, or valuable to California's agricultural community.

Grape vine cultivars, including wine, table, raisin and rootstock varieties, are among the principal horticultural crops supported by Foundation Plant Services. In 1994, the operation moved into its current National Grapevine Importation and Clean Stock Facility. Since then, its programs have more than tripled in size, necessitating expansion for new staff and information technology needs.

Golino holds one of only three grapevine importation permits in the U.S. The vast majority of all grapevines imported from Europe and other parts of the world have come through Foundation Plant Services, which also works with U.S. grape breeders to ensure that new disease- and pest-resistant varieties are available to growers as soon as possible. For example, in 2008, the program released five new grape rootstocks with resistance to nematodes and phylloxera — two of the most damaging vineyard pests.

The service also is responsible for programs for strawberries, fruit trees, nut trees, pistachio rootstocks, roses, sweet potatoes, and chestnuts. These programs have played a key national and international role in distributing new crop varieties and healthy planting stocks.

It takes many years to establish the healthy, live plant collections that are the core of clean stock programs. Clean planting stock programs use disease detection, pathogen-elimination techniques, and isolation strategies to produce, maintain, and propagate healthy planting stock. The collections must be continually protected from infection, monitored for disease, farmed, and documented.

Major gifts for Foundation Plant Services can be pledged over five years. More information about the new Foundation Plant Services building and naming opportunities can be obtained from Deborah Golino at 530/754-8102 or dagolino@ucdavis.edu. ■

2011 Virginia Vineyards Grower of the Year Jeanette Smith

BY **Karen Batalo**

Sunlight and fresh breezes. It sounds like the perfect recipe for the ideal tropical winter vacation destination. Instead, it is Jeanette Smith's recipe for vineyard pest management success. "There is a whole lot more to pest management than chemicals; chemicals should be the last resort," says Smith, the 2011 Virginia Vineyards Association Grower of the Year. "Maximum sun and wind exposure to vines have a huge impact on the ability of diseases and pests to get a foothold."

Smith has a 1.5-acre Traminette vineyard. Her contribution to the Virginia winegrowing industry, however, reaches far beyond her vineyard. Smith also runs VineSmith Inc., a vineyard services company. She consults with 20 vineyards throughout the mid-Atlantic region, developing feasibility studies, business plans, marketing plans and budgets, and guiding vineyard owners and managers through all stages of vineyard installation and management.

She has helped launch over 100 vineyards in her 30-year career in the eastern wine industry. Smith visits her clients' vineyards two to four times each month during the growing season to scout for pest, nutrient, canopy and crop issues, and to recommend management strategies for maintaining vine health.

"I like to be more hands-on, as problems can often go from minor to a catastrophe in just a few weeks," says Smith. "That's why I am reluctant to take on clients whose vineyards are more than a few hours drive away. We are in a crunch period from mid-April to mid-July, when the vines are growing rapidly and diseases and insects are at their peak, so are the weeds. I want to be on-site frequently during that period so that we can be pro-active."

As a consultant, Smith estimates that 75% of the inquiries from her clients involve pest management. Many growers rely on Smith's Vineyard Pest Management Tool Kit, which gives them updated, easy to access information regarding the latest in fungicide, insecticide, and herbicide chemical information. The Tool Kit consists of three posters: one list of fungicides registered for grapes, the second list insecticides, and the third list of herbicides. Each chemical has a long litany of specifications and restrictions which growers have difficulty keeping straight. The posters display all of that information in a table format so that growers can, at a glance, compare their options and select the right material for their situation.

Smith created the posters in 1997 for her own reference, but when growers saw her using them in the vineyards, they wanted to buy them for their own use. Because the selection and restrictions of registered products changes frequently, Smith releases a new edition of the Tool Kit every two years.

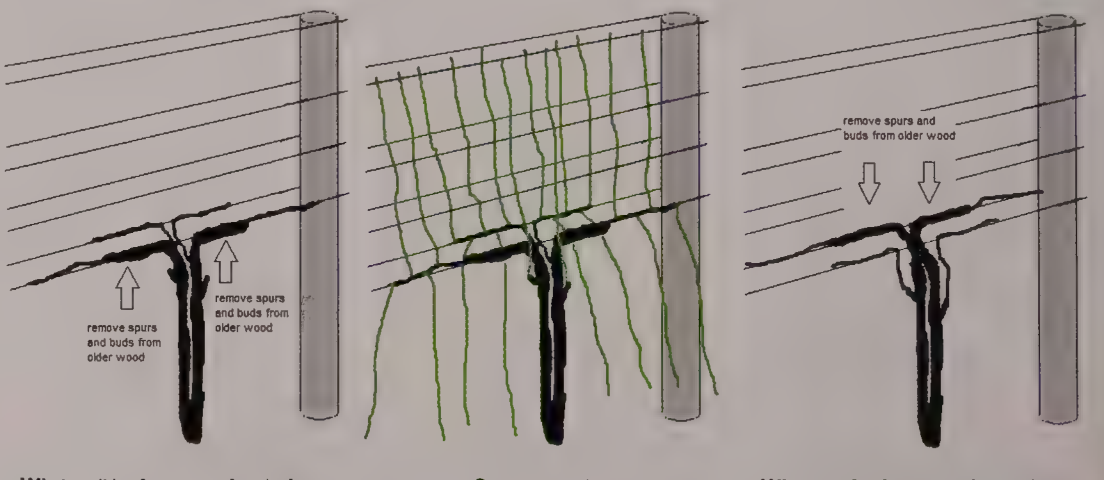
"There are probably very few vineyards in Virginia, and up and down the East Coast, where you can't find this invaluable management tool on the wall of the vineyard manager's office. I, for one, would be at a loss without her Herbicide, Fungicide and Insecticide guides," says Bill Tonkins, president, Virginia Vineyards Association.

"The single most important decision to be made for new and expanding vineyards is site selection," says Smith. "In the East, we frequently face frost after bud break, wet springs, dry summers, and wet harvests. These conditions lead to reduced yields, high vigor, and increased disease pressure. To minimize these hazards, I help my clients find sites with good relative and absolute elevation and good air movement. I work with Alex Blackburn of Soil Foundations to seek out soils with low water-holding capacity and rapid permeability. We lay out blocks with the goals of maximizing sunlight, air flow, and water movement."

Another issue near and dear to Smith's heart is cost management. In an industry where it is difficult to turn a profit, even when doing the most basic management, Smith helps clients develop and maintain budgets. "It is in my best interest to help my clients save money. If their business is not fiscally sustainable, eventually they will fold and I will lose my client," adds Smith.

"Jeanette is to be commended for how she reaches out to our membership and shares her wealth of knowledge," says Tonkins. "She has been a tremendous supporter of the Virginia Viticulture Association members. She is an absolutely super person and I am sure that everyone will agree that this award is well deserved. She and I had an issue with our Traminette grapevines -- they were not fruitful to the extent that we had been removing vines, but in 2011 we experimented with the pruning and we had a wonderful crop!"

Smith explains that many of her


remove spurs and buds from older wood
remove spurs and buds from older wood
remove spurs and buds from older wood

Winter #1 after pruning/tying Summer #1 Winter #2 after pruning/tying

Vine Smith Quadri-care system

clients grow Traminette, a hybrid cross of Joannes Seyve 23.416 and Gewurztraminer. The cultivar has become very popular in the mid-Atlantic region due to its spicy aromas and tolerance to several major diseases. However, Smith has observed that when Traminette is spur-pruned, shoots arising from first count buds are often not fruitful, resulting in yield much lower than growers expect from such a vigorous vine.

In 2009, Smith began experimenting with various pruning and training systems in her own vineyard in an effort to mitigate the unfruitful nature of the first count buds. She found the yields improved with cane pruning, but her five-foot vine spacing was too wide to achieve uniform shoot growth. "I needed a way to leave four 15-inch long canes instead of two 30-inch canes for each vine, so I ran another wire at the same height as my cane wire on the other side of the vine row. Let's call them wire-A and wire-B. In the first year, I leave two 15-inch long canes originating from the trunk along wire-A and two 15-inch long canes originating from arms (last year's canes) along wire-B. I also leave a renewal spur on each trunk. I remove all spur from the arms on wire-B and, once growth begins, I remove any shoots that may arise from the arms on wire-B.

"In the second year, I replace the arms and canes on wire-B with canes that grew from the renewal spurs. On wire-A, I lay down a cane from the end of each arm and remove the spursfrom the arms. Each year, I rotate my arms between wire-A and wire-B. It looks a little goofy, but it allows me to cane-prune vines in low-density vineyards without gaps in the trellis. Maybe I will call it the VineSmith Quadri-cane system -- what do you think?" Smith laughs.

"The 2011 Grower of the Year exceeded requirements for the award, and then some. She is an invaluable resource to growers throughout Virginia and up and down the East Coast, and I am honored to present her with this award," said Virginia Secretary of Agriculture Todd Haymore.

Smith was surprised to win the award. "I expected the recipient to be the owner of a large vineyard. While I have managed many acres of vines over the past 30 years, my own vineyard is only 1.5 acres.'" She has no designs on opening a winery, but has plans to expand her vineyard and continue using it as a testing ground for new ideas such as training and pruning vines, and selling her grapes to local wineries. ■

Since 2005, The Virginia Vineyards Association has been pleased to honor one of its peers with The Grower of The Year Award. The criteria are: the nominee must be an active member of the Virginia Vineyards Association with at least seven years experience managing or operating a commercial vineyard of at least five acres. The nominee must be an active participant in the Virginia viticulture community with a track record of service to the Virginia industry. Last but not least, the nominee must have the respect of his or her peers.

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California Department of Pesticide Regulation

2011 IPM Innovator Award to Gallo's Sonoma Vineyards

E&J Gallo Winery's Sonoma vineyards received a 2011 Integrated Pest Management Innovator Award from the state of California. The state cited Gallo's long history of IPM practices in the winegrape industry, and the company's efforts to stay on the cutting edge of sustainability practice and worker safety, in the announcement.

Two Rock Ranch [photo] (between Petaluma and Cotati, CA) is Gallo's southernmost Sonoma county vineyard with 382 acres planted to Pinot Noir (222 acres), Chardonnay (90), Pinot Gris (49), Sauvignon Blanc (14.4), Riesling (5.9), and Gewurtztraminer (3).

Vine rows are planted to various orientations. "The majority are east/west. Some vine rows run at other orientations; somewhat northeast to southwest to fit the topography," explains Jim Collins, senior director of coastal winegrowing.

Production is 4.5 to 5.5 tons of Chardonnay per acre and 4 to 4.75 tons of Pinot Noir per acre. Some vines have been removed from the 8 x 4 vine spacing, to be 8x8 in some heavier clay soils.

Leaf removal on both sides of the vines begins at set, to achieve maximum sun exposure on the fruit zone. Machinery includes a blower for quadrilateral-trained vines, and suck-and-cut machine for bilateral-cordon vines. More leaf removal is performed at veraison, and post-veraison if needed. The 2011 season required late-season leaf removal to control botrytis and powdery mildew.

Early-season powdery mildew control includes an oil application after budbreak. Fungicides are rotated through the growing season. For botrytis, leaf removal keeps pressure down, and Pristine was applied in 2011 on some blocks.

In 2009, Gallo converted a Spectrum sprayer into a two vine-row weed sprayer for winter herbicide application. The sprayer has an internal fan to blow weeds off the berm in front as it passes. The converted equipment reduces spray passes, and increases the efficacy of chemicals applied.

The PRiME (Pesticide Risk and Mitigation Engine) program measures pesticide use, runoff, and environmental impacts, and is being beta-tested at Gallo's Sonoma ranches, with 2010 and 2011 data collected and loaded into the "engine" and new budgets created for Gallo management to review the effects of current spray regimens and adjust accordingly. "Gallo is one of the first large growers to adopt PRiME, and its use of the system is allowing the PRiME team to make it more effective for other growers," says Collins.

Falconry has been employed to prevent starlings from eating ripe grapes at Two Rock Ranch since 2006. The falconeer arrives in mid-August or at about 18° Brix each year, and works until late October when harvest is completed.

Two Rock Ranch has three raptor perches and six owl boxes for gopher control.

A pocket gopher study at Laguna Ranch began in 2009. Vineyard managers worked with the University of California to evaluate the best methods for gopher control, studying Rodenator, bait, trapping, and fumigation methods. Trapping and fumigation were determined to be the most effective methods.

"This is a partial list of practices we have worked to continuously improve, or where we have been innovators in our field," concludes Collins. "We continuously strive to be leaders in this field, and to help educate other vineyard operators to be successful and sustainable at what they do." ■

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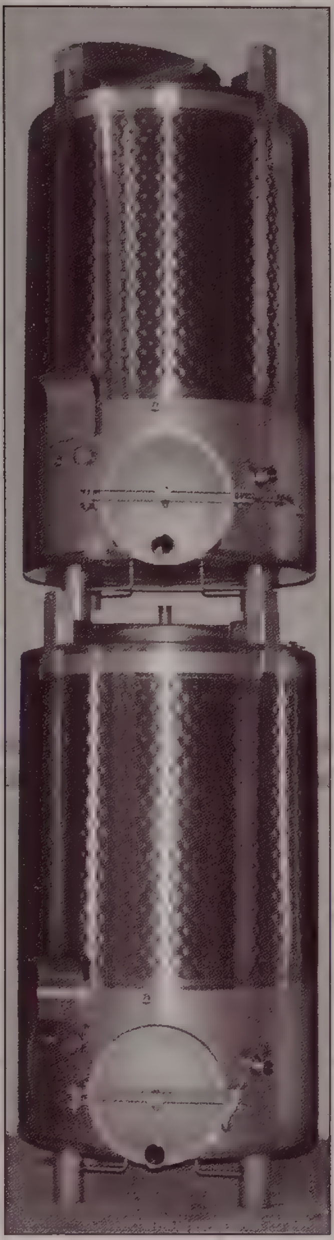

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BOOK EXCERPT

WATER, SOIL, AND THE VINE
AT THE VINE LEVEL

EXCERPTED FROM

The Grapevine
from the science to the practice
of growing vines for wine

Patrick Iland
Peter Dry
Tony Proffitt
Steve Tyerman

11A.3 WATER MOVEMENT INTO/OUT OF LEAVES

11A.3.1 TRANSPIRATION RATE

Vines continually absorb and lose water. Both leaves and berries transpire, but most of the loss of water is through leaf transpiration. Leaves are the main sites where the vine regulates its water loss.

11A.3.2 LEAF WATER POTENTIAL

Diurnal cycle of leaf water potential

During the night, stomates close, transpiration slows or stops and leaf water potential rises (changes to a less negative value) as the vine gradually re-hydrates and leaf water potential equilibrates with soil water potential. Equilibration takes place sometime towards the end of the night. The highest leaf water potential (lowest negative value) is achieved pre-dawn. After sunrise, the stomates open, transpiration takes place and the leaf water potential starts to decrease (changes to a higher negative value). At some point during the day, often around solar noon, the point of lowest (highest negative value) leaf water potential is reached, after which time leaf water potential rises (Figures 11.3, 11.4).

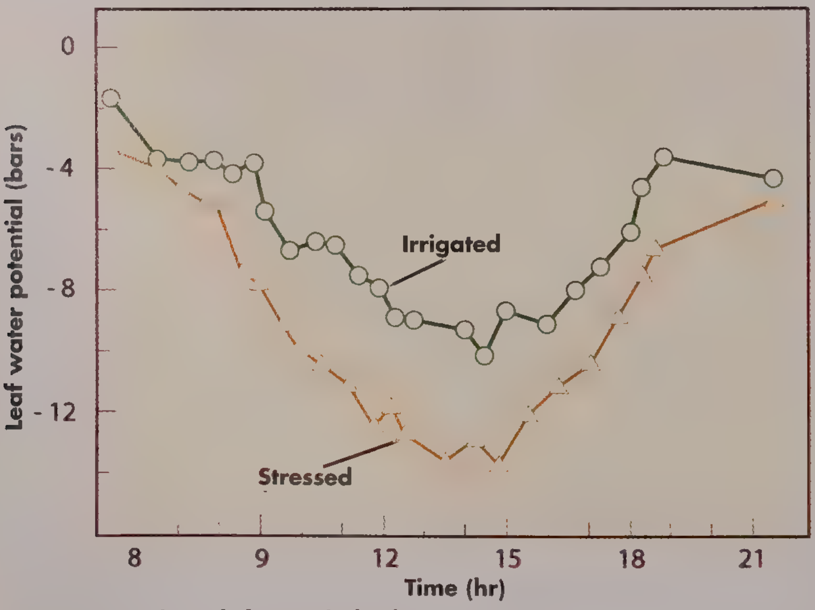

Figure 11.3 Diurnal change in leaf water potential of well-watered and stressed vines (adapted from Figure 6 in Smart 1974, used with permission from the American Society for Enology & Viticulture).

At night, an equilibrium is normally achieved below and above the ground and the measure of pre-dawn leaf water potential, provided that the equilibrium state has been attained, can be taken as an indicator of the average soil water potential.

Change in leaf water potential of water-restricted vines

The leaf water potential of water-restricted vines is lower (higher negative value) than that of well-watered vines and the lowest value is normally achieved earlier in the day (Figure 11.4).

Typically, if soil water availability decreases, leaf water potential gradually declines (moves to a higher negative value). An example of the change in leaf water potential for potted Chardonnay vines over several days is shown in Figure 11.5. Note that in this example leaf water potential measures were taken using a psychrometer. The pre-dawn leaf water potentials (the lowest points in each daily cycle of Figure 11.5) are probably close to the water potential of the soil.

As the soil dries it becomes increasingly difficult for the vine to extract water from the soil. Depending on atmospheric conditions and if water availability continues to decrease, it is likely that, at some stage a point is reached at which the vine can no longer lower its water potential and therefore cannot extract water from the soil. This point is referred to as the permanent wilting point. The permanent wilting point for grapevines varies with variety, rootstock, weather and soil type but generally this happens when leaf water potential is about -1.5 MPa.

Before the permanent wilting point is reached, shoot growth is likely to be adversely affected. If these conditions are maintained the vine will eventually die. In practice, irrigation, where available, would normally be applied to prevent this from occurring.

Measurement of vine water potential

How is vine water potential measured? Water potential of plants cannot be measured directly. It is determined by measuring a parameter that is either directly proportional to water potential or is a major component of total water potential.

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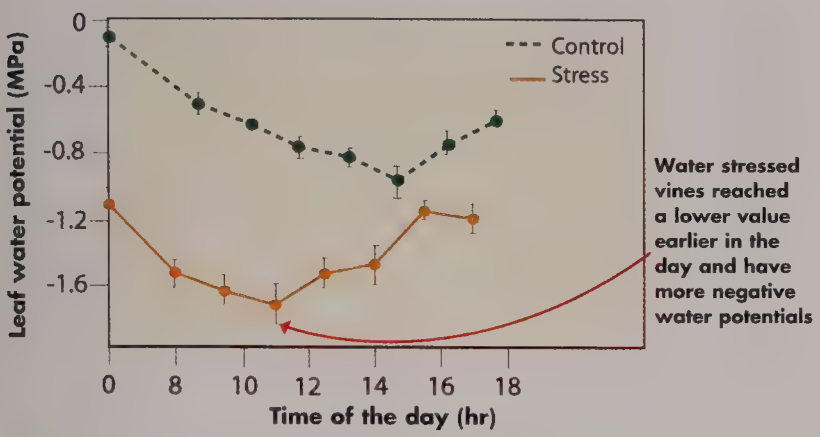

Water stressed vines reached a lower value earlier in the day and have more negative water potentials

Figure 11.4 Diurnal change in leaf water potential of well-watered and water-restricted vines (adapted from Figure 1a in Rodrigues et al. 1993, used with permission from CSIRO Publishing).

One approach is to measure a vine physiological parameter, e.g. leaf or stem water potential with, for example, a pressure chamber (leaves and stems) or a psychrometer (leaves). The most common method is to use a pressure chamber. [16,21]

An example of a pressure chamber and some of the steps in the method are shown in Figure 11.6 — a) a pressure chamber and associated equipment; b) the leaf, with petiole attached, is placed in a bag (to prevent transpiration) and then removed from the shoot; c) the leaf is positioned inside the chamber with the cut end of the petiole protruding from an opening in the lid of the chamber; d) the opening of the chamber is sealed, the lid tightened and pressure slowly applied to the chamber. The pressure forces xylem liquid (sap) out of the leaf and petiole as shown in Figures e) and f). The pressure at which liquid is first observed at the cut area of the petiole (f) is recorded as the balance pressure — this pressure is assumed to be equal and opposite to the tension that was originally in the xylem vessels. The pressure at this point is taken as the leaf water potential.

Another method is to use an instrument called a psychrometer. A psychrometer measures the vapour pressure of air that comes into equilibrium with the tissue. The leaf (still attached to the vine) is placed in the chamber and when an equilibrium is set up with the surrounding air in the chamber the vapour pressure of the air reflects the water potential of the leaf. The psychrometer may be connected to a data logger and the leaf water potential continuously monitored to record a series of readings such as those shown in Figure 11.5.

Vine water potential can also be measured indirectly. Indirect methods rely on a correlation being established

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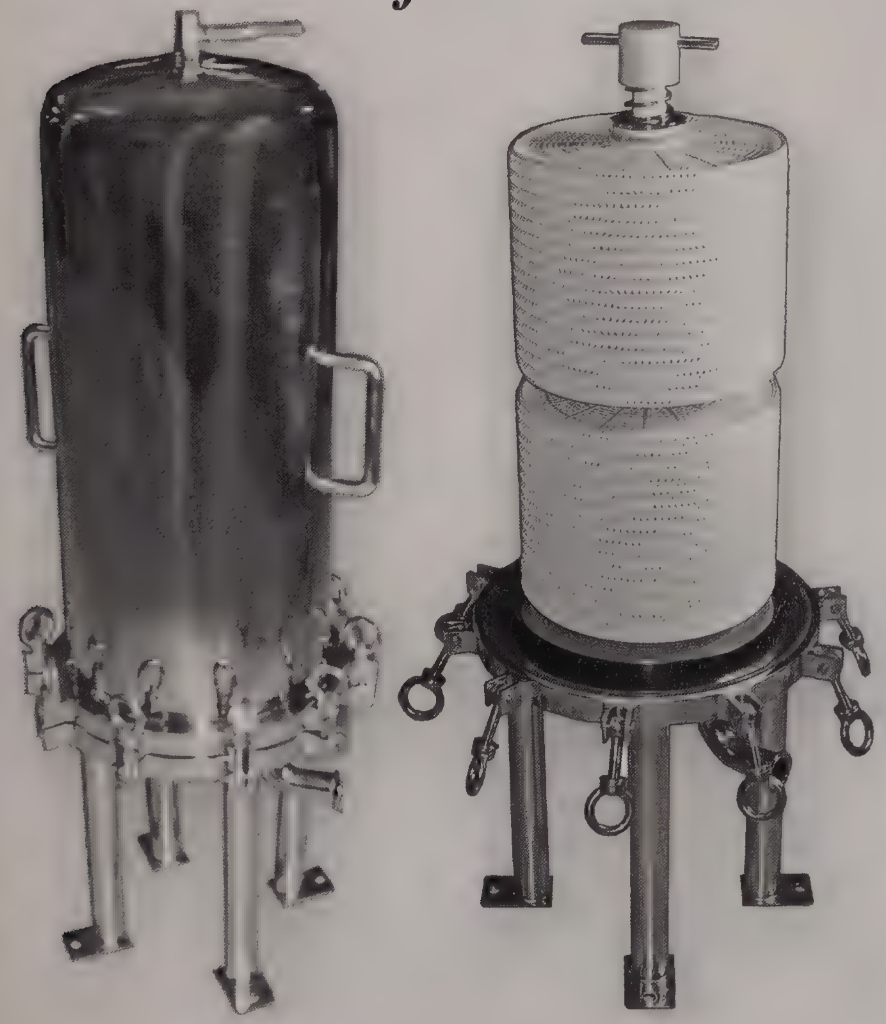

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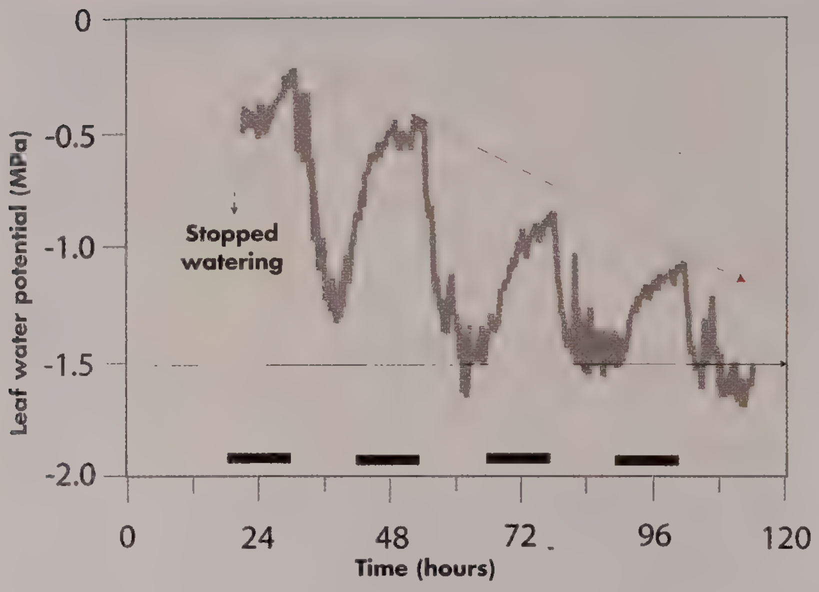

Figure 11.5 The change in leaf water potential (measured by a psychrometer) when water supply was restricted to the roots of potted Chardonnay vines (figure provided by S.D. Tyerman).

between the indirect measure and one of the physiological measures of vine water potential. NIR (Near Infrared) technology is an example of an indirect method. NIR spectroscopy can easily detect water content in leaves since there are strong absorption peaks for water within the NIR range.

NIR instruments use multivariate analysis to relate NIR absorption spectra with physiological measures of leaf and stem water potential,[3,4] (Figure 11.7). The advantages of NIR technology are that it is rapid, non-destructive and has potential for irrigation scheduling.

Some issues relating to the measurement of grapevine water potential: Water potential can be monitored by measuring leaf or stem water potential at various times throughout the day. Measures of pre-dawn leaf water potential, taken before the vine begins to photosynthesise, generally show less variation than mid-day measures. However, pre-dawn water potential does not vary as much in response to soil water deficits as mid-day measures.

Measurement of stem water potential may be more suitable for monitoring vine water status of anisohydric varieties, while measurement of stomatal conductance may be more suitable for isohydric varieties.[23] (The terms anisohydric and isohydric are explained later in this chapter).

H. Schultz and M. Stoll and S. Tyerman *et al.* discuss current and emerging technologies for measuring vine physiological parameters.[20,23] Some of the new techniques have the advantage that they are non-invasive, e.g. remote sensing techniques. Others have the advantage that they can be monitored continuously, e.g. sap flow sensors (see Figure 11.9).

The use of infrared imaging of vine canopies to measure

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leaf temperature as an indicator of stomatal conductance has potential for rapid data collection for planning and application of irrigation scheduling.[12,14]

Measurement of carbon isotope composition ($\delta^{13}C$) of sugars in the juice of berries can also act as an indicator of water use in grapevines.[2,6,8,9,20] The advantage of this method is that it integrates measurements over a period of time. Sugar $\delta^{13}C$ and pre-dawn leaf water potential were significantly correlated for field grown grapevines.8 This is due to stomatal closure, which reduces the discrimination of $\delta^{13}C$ (numbers become less negative as pre-dawn leaf water potential declines). The biochemical basis and the mathematical formulae for determining the values from this method are described by G. Farquhar *et al.* and H. Schultz and M. Stoll.[6,20]

The best method of measurement of vine water potential for determining the level of vine water stress, whether it is better to measure leaf or stem water potential and the best time of the day to take the measure are still being debated in the literature. Relevant papers to consider are L. Williams and T. Trout,[24] T. Sousa *et al.*[21] and those mentioned above.

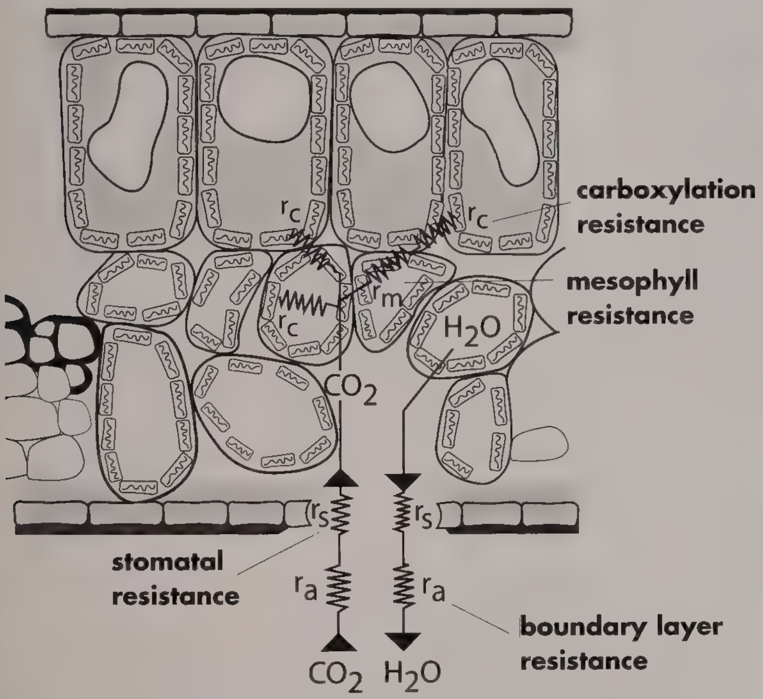

Figure 7.17 Diagrammatic representation of a cross-section of a grapevine leaf showing the pathway and resistances for carbon dioxide and water through a stomatal pore and inside the leaf.

A goal is to develop techniques that integrate physiological responses on a single leaf level into canopy and whole vineyard responses — structural-functional modelling may assist in achieving this.[20]

11A.3.3 LEAF TRANSPIRATION RATE

When water in the transpiration stream reaches a leaf it passes through stomates, located in the underside of the leaf, into the air. The volume of water lost per unit time (the transpiration rate) is influenced by many interacting factors. The two major factors are the difference in water vapour concentration between the air spaces in the

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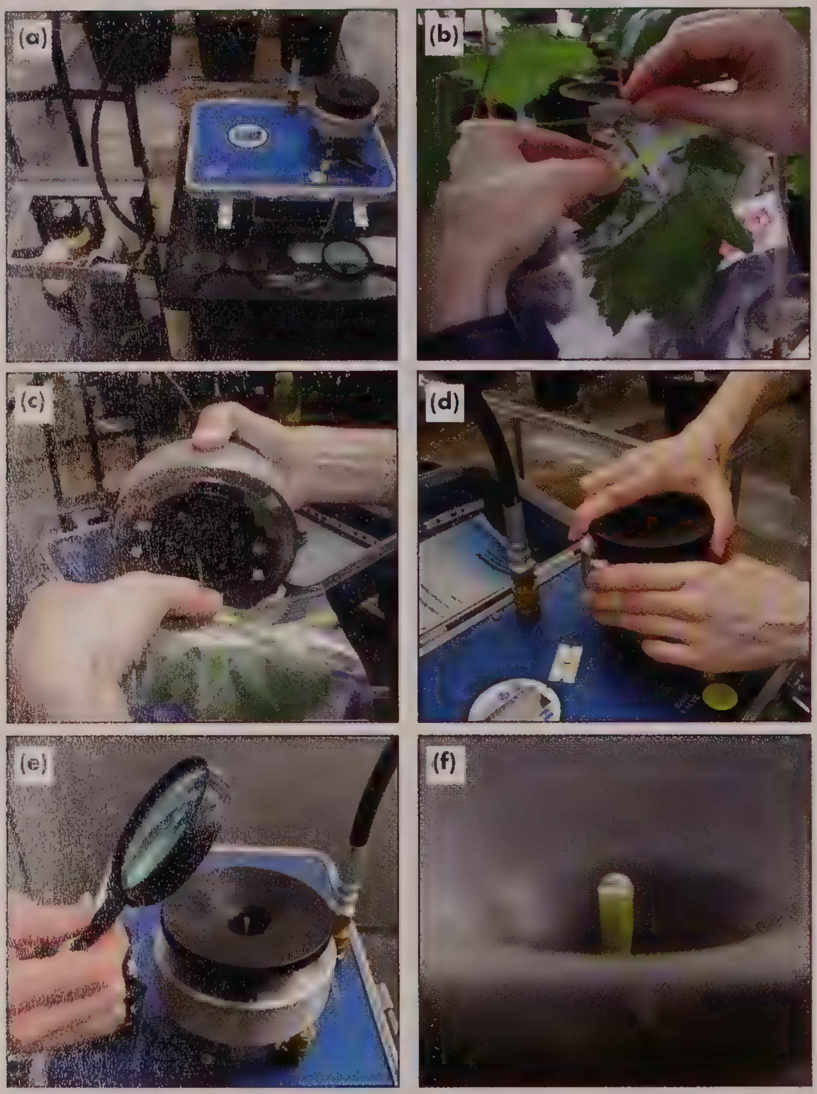

Figure 11.6 A pressure chamber (top, left) and some steps in the procedure for the measurement of leaf water potential as described in the text (photographs S.D. Tyerman).

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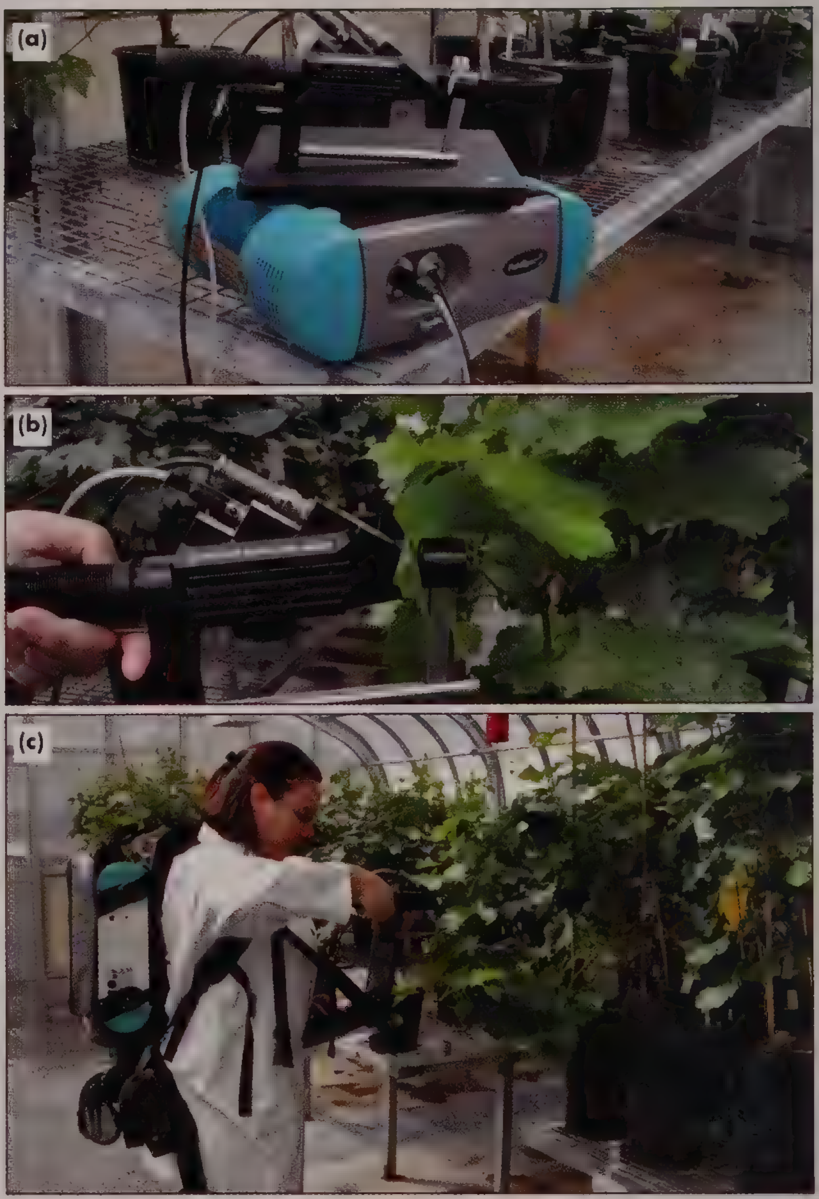


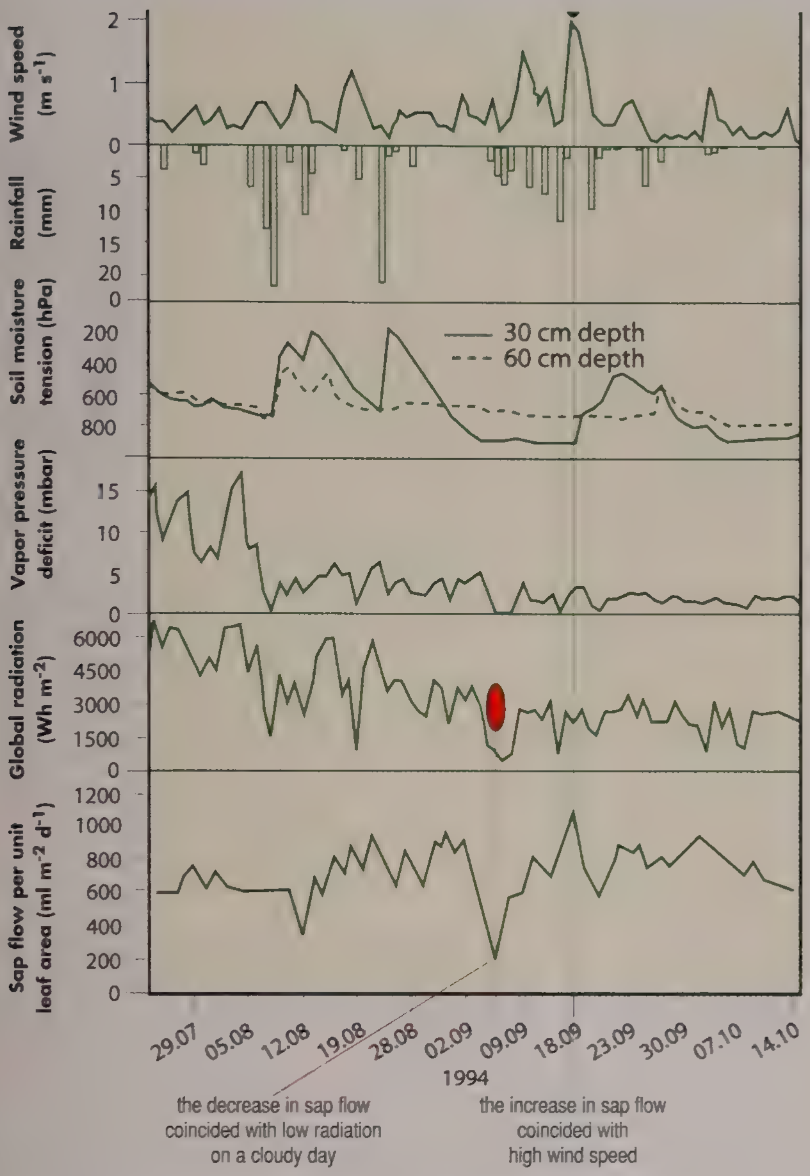
Figure 11.7 (a) Near Infrared instrumentation, (b) the probe pointed at a leaf, light from the probe is reflected back into the instrument and from this the absorption spectrum can be obtained and (c) the equipment set up in portable mode (photographs R. De Bei and S. Fuentes).

leaf and the external air, and the diffusion resistance (r) that impedes the movement of water out of the leaf (see Figure 7.17).

Both environmental and vine factors influence transpiration rate. Evaporation from a wet surface depends on three primary variables — solar radiation, atmospheric vapour pressure deficit (VPD), and wind speed; these are discussed below.

If leaf transpiration rate is high, then leaf water potential declines (becomes more negative) since the increased flow through a constant hydraulic resistance requires a larger gradient. The gradient from the soil to the roots also increases to accommodate the extra flow, i.e. the water potential in the root becomes more negative.

Solar radiation: Available energy from solar radiation drives evaporation from a leaf. Higher radiation increases leaf temperature and this results in an increase in the saturation vapour pressure within the leaf — thus evaporation increases.



the decrease in sap flow coincided with low radiation on a cloudy day

the increase in sap flow coincided with high wind speed

Figure 11.8 Measurements of wind speed, soil moisture tension, vapour pressure deficit (VPD), radiation and sap flow of Riesling vines over a period of time (adapted from Figure 2 in Schmid and Braun 1997, used with permission from the International Society of Horticultural Science).

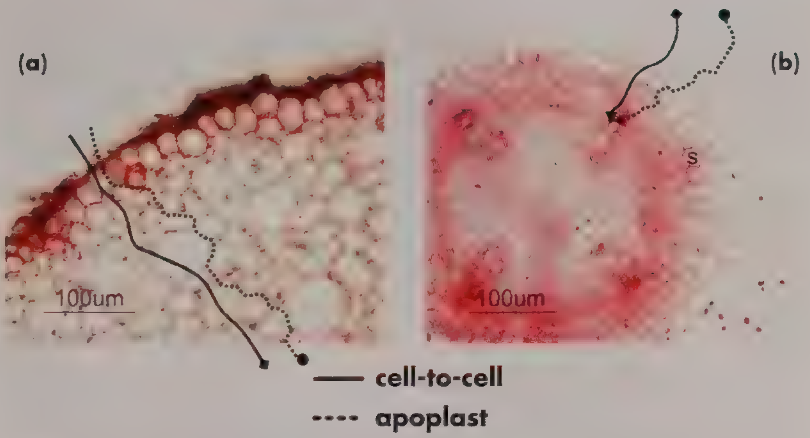


Figure 2.47 Transverse sections of a Grenache root 25 mm from the root tip stained with Sudan Red 7B for two hours to show suberin lamellae. The pathways of radial water movement to the xylem across a grapevine root are indicated by the solid (cell-to-cell) and dashed (apoplast) lines. Photograph (a) indicates the outer cortex with exodermis and shows the flow path entering through passage cells and then flowing through either the cell-to-cell or the apoplast pathway. Photograph (b) shows the stele and endodermis with some cells in the endodermis showing suberin lamellae (s) (adapted from Figure 1 in Tyerman et. Al. 2009, used with permission from Springer Science + Business Media B.B.: photograph S.D. Tyerman).

Evaporation at a location is determined by measuring evaporation of water contained in a standard sized pan. Evaporation from a standard pan has been declining on both a global and continental basis over the last 50 years. This has been attributed to declining incoming solar radiation, despite the fact that the global average temperature has been increasing.[17]

VPD: Vapour pressure deficit (VPD) is a measure of the partial pressure of water in the atmosphere relative to the saturated value in the atmosphere. This term is more useful than relative humidity (RH) because it reflects the actual evaporative power of the atmosphere. Potential evaporation is much higher at a higher temperature than at a lower temperature even though the relative humidity may be the same. The VPD at 30°C and 50% RH is 4.05 kPa while at 20°C and 50% RH, VPD is 1.12 kPa.[19]

Under high VPD conditions the water vapour concentration of the air is lower than under low VPD conditions and thus transpiration rate is greater under high than low VPD conditions.

Wind: The layer of air in the immediate vicinity of the leaf surface is called the boundary layer (see Figure 7.17). When this layer of air is still, the water vapour concentration is high and the layer resists water moving out of the leaf (termed the boundary layer resistance). When wind speed increases it disrupts the boundary layer thereby

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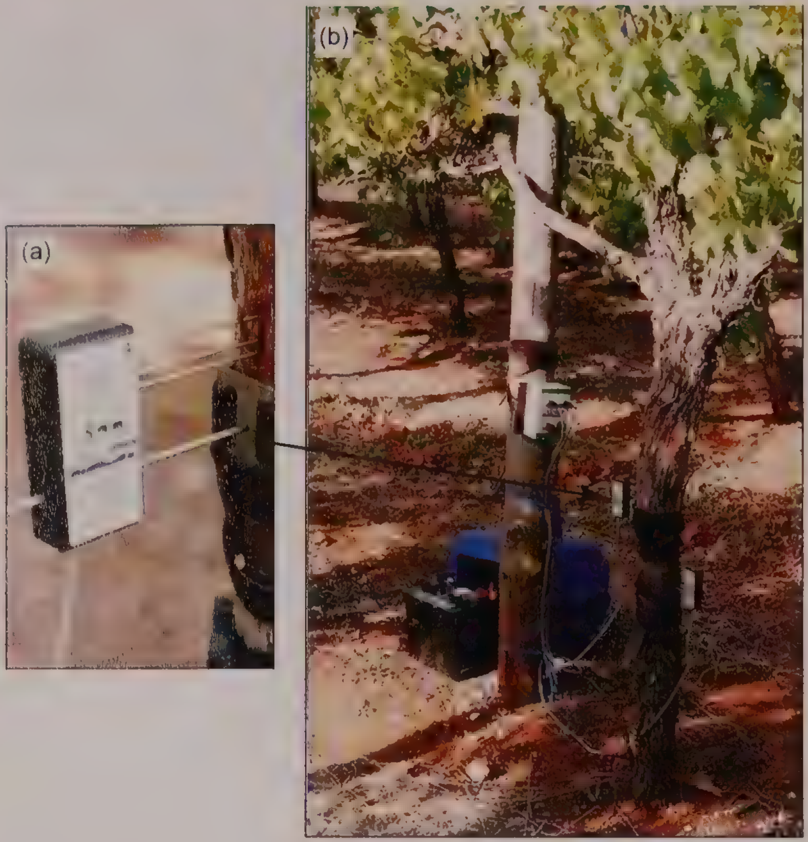

Figure 11.9 (a) Sap flow probes inserted into the trunk of a vine, and (b) the data logger and power supply adjacent to the vine (photographs T. Proffitt).

decreasing resistance for water movement; and transpiration increases.

An example of the effect of environmental conditions on grapevine transpiration rate is given in Figure 11.8. Sap flow rate is used as an indicator of transpiration rate — decreased sap flow rate was associated with low radiation and increased sap flow rate was associated with an increase in wind speed.

How is transpiration measured? Transpiration can be measured using an instrument called an infrared gas analyser (IRGA) or via sap flow sensors (Figure 11.9).

How is sap flow measured? Methods to measure sap flow utilise the convection of heat in the flowing transpiration stream.

There are essentially three methods: heat pulse, stem heat balance (steady state), and heat dissipation.

The heat pulse technique measures the velocity of sap flow.[11] A heating device is inserted into the conducting xylem a certain distance below a temperature sensor, also inserted in the xylem. These systems may have a third probe inserted on the upstream side of the heater to correct for heat diffusion. The implantation of the probes in the stem causes damage to the xylem and a "wound factor" is required to correct the velocity reading.

Heat balance (or null-balance) methods inject heat

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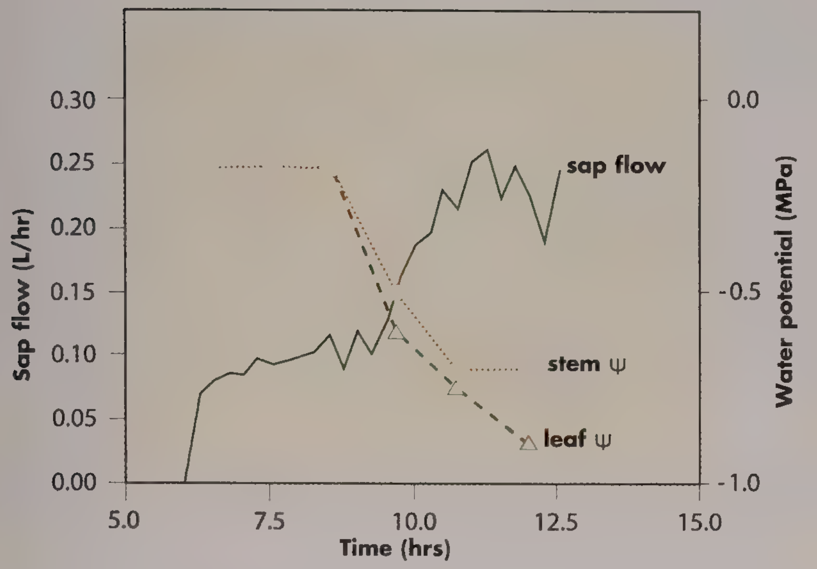

Figure 11.10 Change in sap flow, stem Ψ and leaf Ψ over several hours (figure provided by S.D. Tyerman).

so that a constant difference in temperature is sensed between two points on the stem. This has the advantage of not overheating tissue at low flow rates.

Heat dissipation methods determine the amount of heat dissipated from a constant amount of heat applied. These are only suitable for small stem diameters.

Current methods for measuring sap flow are discussed by P. Gonzalez-Altozano et al.[10] and P. Braun and J. Schmid;[1] in the former study correlations with evapotranspiration and onset of water stress were assessed in a horticultural setting.

New technologies for monitoring vine transpiration are being investigated; for example, a microtensiometer, that is designed to be embedded into the xylem of vines and provide continuous monitoring of stem water potential.[13,15]

Sap flow can also be observed at night.[5] This phenomenon may relate to some water loss by leaves,[18] but there is also a component of night sap flow that accounts for rehydration of leaves and wood during the night after dehydration during the day.

11A.3.4 FLOW RATE

The rate of water flow throughout the vine is determined by the differences in water potential between any two points along the pathway divided by the resistance between the two points. The overall resistance is determined by root, xylem, and leaf resistances. Leaf and root resistances are larger than xylem resistance. Leaves can account for 30% to 80% of the whole plant hydraulic resistance. Xylem resistance is related to the number of vessels and their diameter. End walls account for about 60% to 80% of the xylem hydraulic resistance, suggesting that vessel length is an important determinant of water transport efficiency.

Root resistance is comprised of axial and radial components. The axial resistance is largely due to the xylem vessels — it is much lower than the radial component. The radial component is comprised of resistances due to flow across cell membranes and flow through cell walls in the roots (see Figure 2.47).

Measurements of water potential of leaves at different

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positions along a shoot indicate that stem resistance is low and that the major resistance to water flow in grapevines is likely to be the root resistance.[7]

> The greatest resistance to the movement of liquid water occurs at the soil to root interface and the greatest resistance to the movement of water vapour occurs at the leaf to air interface.

11A.3.5 WATER POTENTIAL THROUGHOUT THE VINE

A leaf can be placed in a pressure chamber to determine its water potential, but this method is not applicable for stems. However, if a leaf is covered in foil and put in a plastic bag, that leaf will equilibrate with its connected stem. Therefore, if leaf water potential is measured after an equilibrium has been attained the value obtained is a measure of the water potential of the stem.

One experiment (S.D. Tyerman, unpublished) showed that early in the morning sap flow increased, then stabilised, and then recommenced, in this case, about 10AM (Figure 11.10). Until the point at which sap flow 'kicked in,' the leaf and stem water potentials were similar and in equilibrium, but as sap flow increased, the leaf and stem water potentials diverged. Leaf water potential dropped to a lower level than the stem water potential, indicating that water was being pulled to the leaves from the stem.

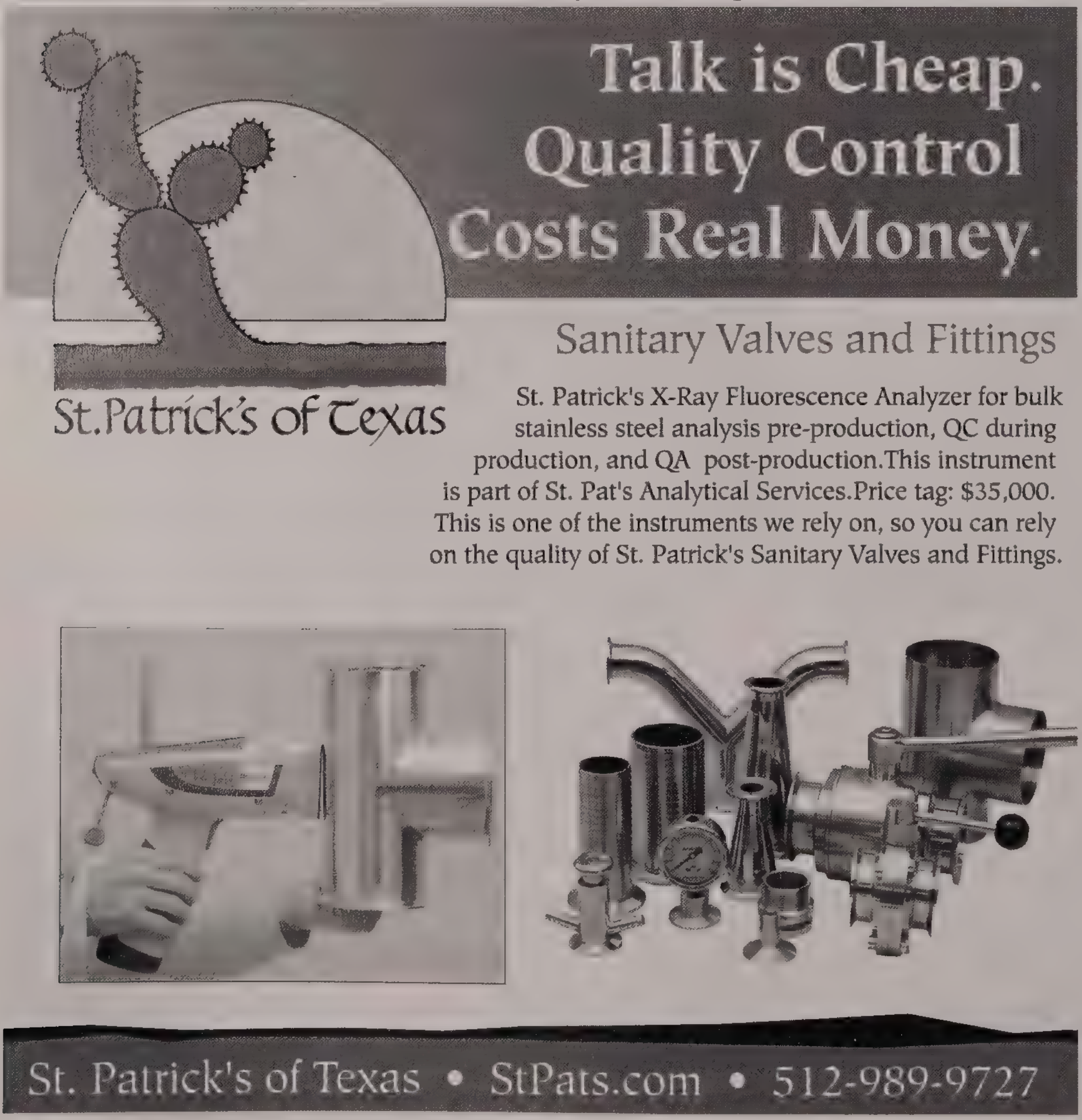
The difference in behaviour of leaves and stems is important in determining how to measure water potential (and estimating water stress) in the vine.

Measurements of water potential and sap flow at several points along long cordons of Shiraz vines throughout the day (J. Tregeagle and S.D. Tyerman, unpublished) showed that:

- The stem water potential was the same for shoots positioned close to the trunk as for shoots positioned at the end of the cordon indicating that the hydraulic resistance in the cordon was low.
- Sap flow rate responds to the size of water potential gradients and hydraulic resistances/conductances in the soil plant continuum. Thus, if the vapour pressure deficit of the air increases (more negative air water potential) and if there is no change in stomatal conductance then there will be an increase in transpiration and sap flow rate. On the other hand, if the soil water potential declines initially, there may be a decline in sap flow rate until the vine re-equilibrates and its water potential declines. These two examples assume no change in resistances within the pathway; however, in the field the vine is always regulating its water flow. This regulation occurs in the liquid water pathways in the roots and leaves via aquaporins, and in the water vapour phase via stomates in the leaves.

The greatest difference in water potential is at the interface of the interior airspaces of the leaf and the surrounding air — therefore, the main point of control is at the stomates. The excessive gradient, e.g. 99 MPa, and the possible damage to the leaf through high transpiration rate means that the stomates react to preserve water in the vine. The stomates may partially or fully close to prevent water loss and, as a result, photosynthesis will decrease. Because excessive water loss can result in more severe damage than a temporary loss in photosynthesis, stomates close when water supply is low — the vine suffers a short-term loss for a long-term gain. ■

***References for this section of the book will be available at* www.practicalwinery.com**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Harvesting Rockpile Zinfandel
Photos by John Florence Jr.

ZINFANDEL

COMMONER or ROYALTY?

BY **Jack Florence Sr.,** Rockpile Zinfandel grower, Healdsburg, CA

Zinfandel a commoner? A second cousin once removed of the royal family of fine European wines? Cabernet Sauvignon, Chardonnay, and Pinot Noir are members of the same family and the family name is V. vinifera. Zinfandel is as much a member of the family as they are, but Zinfandel is an outcast everywhere in the wine world except California. How can this be?

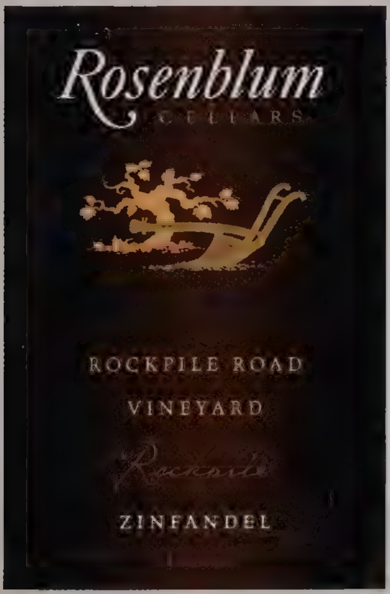
Other than the obscure Mission grape brought to California by the missionaries in the mid-eighteenth century, no wine grape variety has been in California longer than Zinfandel. During all that time, Zinfandel has been one of California's favorite wines.

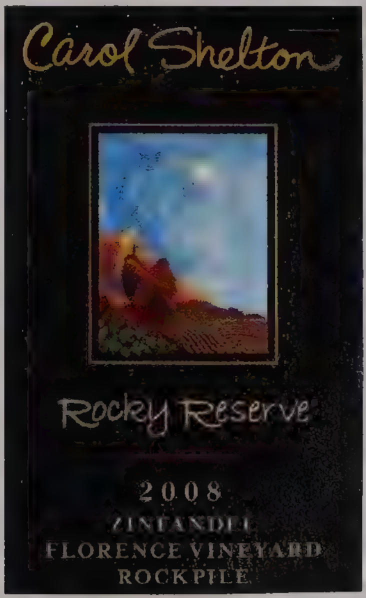
But the "sophisticated" wine drinker in eastern U.S. cities has never been impressed with Zinfandel; for them, to be good, wine must come from a member of wine's royal family Cabernet Sauvignon, Merlot, or Pinot Noir.

Now in the opening years of the twenty-first century, it is time that California winegrowers show the eastern U.S. in particular and the world in general, that Zinfandel is a first cousin to the French bluebloods and a more pleasing cousin at that. Here is the untold story of California's storied variety.

Until late in the 20th century, the California wine industry was focused on blends and in the world of Chablis and Burgundy, there was little interest in specific varieties. But with the introduction of the American Viticultural Area (appellations) in 1978, California began its focus on varieties. Now questions were asked about the state's favorite variety.

Zinfandel is from the grape family *V. vinifera*, the species native to Europe. But if Zinfandel was a European grape, where in Europe did it grow? If Zinfandel was so great, how come it did not grow among the Cabernet Sauvignon vine-





yards of Bordeaux or the Cote d'Or in Burgundy?

How and when, did it get to California? The most intriguing question of all; if Zinfandel is so great why is there no record of the wine gracing the tables of kings and nobles across Europe? If there were, we can be sure that Zinfandel would be a favorite today among the world's fine wines.

Carol Meredith, U.C. Davis professor and renowned plant scientist, used DNA analysis in 2001 to show that Zinfandel is a Croatian variety that grew in the area of Split, a city along the east coast of the Adriatic Sea. Further DNA analysis showed that Primitivo, a variety grown for centuries in Puglia, Italy, on the west coast of the Adriatic Sea, is also Zinfandel -- a different clone, but still Zinfandel.

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More recent studies suggest that the DNA profile of today's Zinfandel matches the genetic profile of Tribidrag, a variety that flourished in Croatia 600 years ago. This would make Zinfandel a European variety some 300 years older than Cabernet Sauvignon. These findings answered the question where, but to complete the story we need to know why the variety did not grow in France and how and when the grape reached California? These questions pose a special challenge for wine historians as no one knows for certain the name(s) Zinfandel was known by in Europe.

Charles Sullivan tackled the issue of how the grapes got to America. He makes a good case (in his book *Zinfandel, A Story of a Grape and its Wine* - UC Press) for concluding that Zinfandel cuttings were sent from the Schonbrunn Imperial collection in Vienna, Austria to Long Island (NY) nurseryman George Gibbs sometime between 1822 and 1829.

But the vine could have taken another route, this one across continental Europe, eventually landing in England. The evidence is circumstantial but events in Europe around the turn of the 19th century support this hypothesis. At that time, Jean-Antoine Chaptal, a Parisian chemist and leading industrialist in France, turned his attention to grapevines. Under the aegis of Napoleon, Chaptal collected 1,400 vine samples from all over Europe. If Zinfandel had been part of the Vienna imperial collection, it is likely that Chaptal would have included it in his collection.

Chaptal's vines were planted for study in the Luxembourg Gardens. If Zinfandel was among the vines, the French would probably have taken the variety, so different in appearance from their familiar wine grapes, to be a table grape. That the French might have missed Zinfandel as a wine grape is no surprise to anyone who has ever grown the grapevine.

V. vinifera vines like Cabernet Sauvignon and Pinot Noir almost always yield tiny berries holding mostly seeds. Not Zinfandel. It's berries are huge, the clusters easily weighing two to three times that of Cabernet clusters. Unfortunately, getting Zinfandel ripe in the Paris climate, and avoiding bunch rot would have been a challenge bordering on the impossible, and Zinfandel would have been a failure in Paris.

In 1817, a deputation of the Caledonian Horticultural Society departed Scotland for northern France, Holland, and Flanders. It had been 28 years since the French Revolution, and France had been at war or near war ever since.

With Napoleon in exile, peace had returned and the Scots were anxious to visit the mainland to explore the state of horticulture in the region. The group visited the Luxembourg Gardens and reported that "the grounds contained all varieties of vines known to be cultivated . . . in Europe." 300 varieties in all were grown there -- generally one plant of each variety. The group was hunting for plants not known in the British Isles. There is a good chance they would have brought Zinfandel back to Scotland if a cutting was to be found in the Gardens, particularly if the vine was considered a table grape.

Zinfandel would not have fared well in England, even as a table grape. It would not have taken many years for the Scots or Brits to have learned how poorly the variety was suited to the cool, wet environment of the British Isles and the vine would have been consigned to the compost heap. But the vine could well have escaped that fate for a handful of years, long enough for a few sticks to have been included in a shipment of specimens sent to American nurserymen around 1820.

Interest in table fruit was high among American horticulturists during the early years of the 19th century, and American nurserymen eagerly sought plants from "the old country" that might do well in the "new world." Sometime in the 1820s, England shipped a variety they called Black St. Peters to the new world where the variety showed promise initially as a table grape.

Unfortunately Black St. Peter's failed in the eastern U.S. climate, but lasted long enough to get shipped to California in the 1850s, by which time John Fiske Allen (Massachusetts Horticultural Society horticulturist) was reporting that Black St. Peter's and the vine they knew as Zinfandel -- from the Gibbs collection -- were one and the same variety.

Sullivan says, "Whatever arrived in California in the 1850s under the name, Black St. Peters, and survived in the state's vineyards in later years was the same vine that was, by the 1870s, universally accepted as the Zinfandel in the Golden State."

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Was there a Black St. Peters growing in the Luxembourg Gardens when the Scotts arrived to get one of everything? An undated paper published by the J. Pedroncelli Winery reports that "Antoine Delmas (a French immigrant) claimed to (have) imported the grape (Zinfandel) from Paris" for his Santa Clara County Zinfandel vineyard in 1852. It is not clear what name Delmas used in ordering his vines.

Fortunately for the vine and wine drinkers everywhere, the seemingly doomed variety found itself in California, where it succeeded beyond its wildest dreams. Born again as a wine grape, all that remained of the remarkable journey was to find the place, the one above all others, where the vine could grow well and at last, show the world its remarkable fruit. That place would be the inland valleys and mountainsides of northern California.

There is one more question, the most important one of all: why is it that in the widely reported history of wine in Europe, there is no mention of Zinfandel or even of a wine suspected as being Zinfandel?

A couple of explanations can be offered. The climate of the Croatian coast offers warm to hot, dry summers, but not dry for long enough. The beautiful region of Split is "cursed" if you are a Zinfandel vine, with rainfall averaging some four inches in the month of September.

Prime Zinfandel appellations Rockpile and Dry Creek Valley in Sonoma County, see less than ½ inch of rain in that month, and growers live in fear of that ½ inch. There is no way that Zinfandel can survive four inches of rain in September, when the berries are fat and the clusters packed dense with sugar-laden grapes.

No place in France, Croatia or England provided the environment the fussy Zinfandel demanded; hot days, cold nights, and dry weather before harvest.

There would have been no worries about rain in Puglia, and the area is certainly hot enough. The Italians harvest fully ripe Primitivo in August even though there is no threat of rain in the extremely dry Puglia region. Puglia is a Zone-four area in the Winkler heat scheme. Zone four is very warm; the lower San Joaquin Valley in California is Zone four.

No one in California would dream of growing premium Zinfandel in Bakersfield; the heat in that area produces grapes that are fully ripe early in the season but lacking heat-liable grape acids, and it is the acids that separate jug wines from premium wines.

Too wet in Croatia and too hot in Italy, impossibly cool and damp in France and England. Nowhere in all of Europe would Zinfandel be happy. A brief stop along America's Atlantic seaboard and then, like so many Americans, onto the west. After centuries of wandering, Zinfandel finally found a home and a climate that met its demands. The grape has never looked back. Europe? OK for some, but not good enough for Zinfandel. ■

Phenolic composition of Syrah

Continued from page 28

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Advancing the frontline against BRETT

AWRI breakthrough offers potential to transform the battle against *Brett*

BY Christopher D. Curtin, Anthony R. Borneman, Paul A. Henschke, Peter W. Godden, Paul J. Chambers and Isak S. Pretorius, The Australian Wine Research Institute

If there is one battle that has united the global wine industry, that battle is against "*Brett*'" the yeast with the potential to spoil wine, with its "medicinal," "Elastoplast," and "barnyard" characters. For more than two decades, the Australian Wine Research Institute (AWRI) has worked to give winemakers the upper hand against *Brettanomyces* through a program of dedicated research, which quickly delivered a practical, application-ready control strategy.

The latest breakthrough is a world first: AWRI researchers have sequenced the genome of a *Brettanomyces bruxellensis* strain, in fact, the most dominant strain present in Australian wineries, revealing new insight into the yeast's resistance to sulfites; examining the likelihood of a "super" strain; and opening opportunities for winemakers to tackle spoilage more efficiently.

Friend Or Foe?

When N. Hjelte Claussen, of the New Carlsberg Brewery in Denmark, first isolated a *Brettanomyces* yeast in 1904, he was not to know the enduring significance of his discovery. Claussen was concerned with beer, primarily, and was investigating what gave British ales their unique character.

His discovery led to *Brett's* now infamous name -- *Brettanomyces,* or "British sugar fungus." Claussen noted with interest that the yeast he had isolated did not "sporulate:" it did not produce or release spores. He also said it was "essential for production of English 'stock' beers," a style the Danish brewers were having trouble replicating.

Since then, *Brett* has been recognized as ubiquitous in the environment. It is commonly found in breweries and wineries – anywhere, in fact, that fermentation occurs. It has been found in fermented teas and detected in yogurt drinks. Its discovery in Belgian breweries, in Lambic ales for example, led to its more recent scientific name, *Brettanomyces bruxellensis,* which is now used to incorporate all strains of *Brett* relevant to wine.

In the wine industry, it has been largely associated with red wine stored in barrels, but has also found its way into white table wines and bottle-fermented sparkling whites. In the past, some winemakers thought that a touch of *Brett* could enhance sensory experience of *terroir* and highlight rustic, earthy characters.

Today's winemakers see *Brett* as a persistent problem. Studies have shown that consumers dislike the characteristic aroma and flavor produced by the yeast, which are often described as "Elastoplast," or smelling and tasting "medicinal." On the palate, *Brett* produces a character commonly described as "metallic" or "excessively drying." The verdict from consumers has been clear: its presence is unsavory; it is not a winemaker's friend.

Understanding the enemy

The compound largely responsible for *Bretty* characters is 4-ethylphenol. It is now well-accepted that *Brettanomyces bruxellensis* is the key wine micro-organism responsible for converting phenolic acids in grape must and wine into this, and related, volatile phenols.

When levels of 4-ethylphenol and its "sister" compounds 4-ethylguaiacol and 4-ethylcatechol reach noticeable levels, consumers say they dislike the wine. They are often unable, however, to explain why. Winemakers have been dealing with an enemy, therefore, that has been difficult to pin down and even harder to eradicate.

Wine researchers throughout the world have demonstrated the scale of the problem: revealing ubiquitous, undeniable links between *Brett* and the spoilage of red wine. Despite their research, the inside story of Brett has not been fully investigated. In the past, there has been little investigation into how the yeast evolved various traits to survive a harsh wine-producing environment, or why some strains of the yeast respond differ-

New Tactics

- Sequencing the genome of the most common strain of *Brett* in Australian wineries is giving winemakers new "weapons" in the fight against spoilage.
- The gene responsible for unpleasant *Bretty* characters has been traced, offering a new target to combat the *Bretty* taste and smell disliked by consumers.
- A key gene involved in sulfite tolerance has been found, so that variability in tolerance between different strains of *Brett* can be better understood.
- Clearer diagnostic tests are now more likely, identifying whether outbreaks of *Brett* are more or less tolerant to sulfite treatment. When available, these tests will give winemakers the upper hand in knowing what "weaponry" to use.

ently to sulfite treatments.

To address this gap in knowledge, researchers at the AWRI embarked on a sustained program of more than 20 years of research. The journey of that research has seen the introduction of effective counter-measures; dissemination of new intelligence to combat *Brett*; and, more recently, the application of genomics technology to crack the code of the "enemy," so that winemakers are able to target *Brett* more effectively.

Early victories

One of the key components of any successful *Brett* control strategy is the use of sulfites. Added in the right amounts, at the right time, sulfite can be highly effective. However, finding the right balance is not easy.

In the 1990s, winemakers were struggling to keep *Brett* under control. Their defense strategy was under attack; and not only by the yeast itself. There was growing concern regarding the use of sulfite in wine and its

BATTLING *BRETT*

Early victories against "*Brett*" were won by Australian winemakers through implementation of a control strategy built upon five key components:

1. **Healthy and complete alcoholic and malolactic fermentations.** Sluggish or stuck fermentations are more likely to leave residual sugar, providing *Brett*-accessible food. A slow malolactic fermentation, when turbidity is high and SO_2 is low, keeps the door open for *Brettanomyces* to grow.
2. **Fewer, more effective SO_2 additions during winemaking and improving understanding of how SO_2 works.** SO_2 added at harvesting or crushing helps minimize wild yeast and bacteria populations, reducing risk of a sluggish fermentation. Post-MLF is the time for the largest SO_2 addition – achieving molecular SO_2 concentrations of more than 0.6 mg/L remains one of the key means to avoid *Brett* blooms. Adding SO_2 when wine turbidity is low, maximizes its effectiveness.
3. **Sound topping wine and barrel management regimes.** The easiest ways to spread *Brett* around the winery are by putting clean wine into contaminated barrels, or through use of topping wine that has been stored unullaged with critically low SO_2 levels.
4. **Sanitation.** Rapid formation of volatile phenols, key *Brett* spoilage compounds, requires exposure to viable *Brettanomyces* yeast and a wine composition conducive to *Brettanomyces* growth (residual sugar, low concentrations of molecular SO_2). Reduction in the risk of exposure to the yeast, and lowering of its population, are maximized by appropriate sanitation.
5. **Filtration.** If a wine has a viable *Brettanomyces* population, well-performed filtration of the appropriate grade is advisable to avoid variable spoilage in the bottle.

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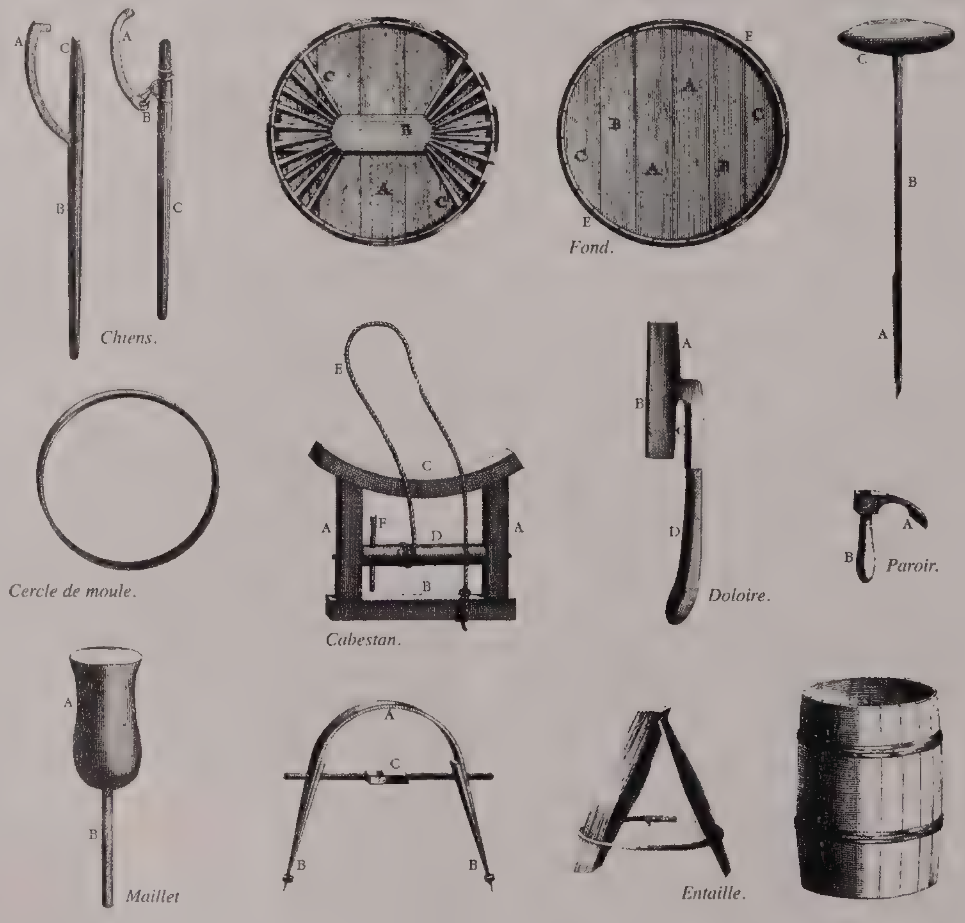

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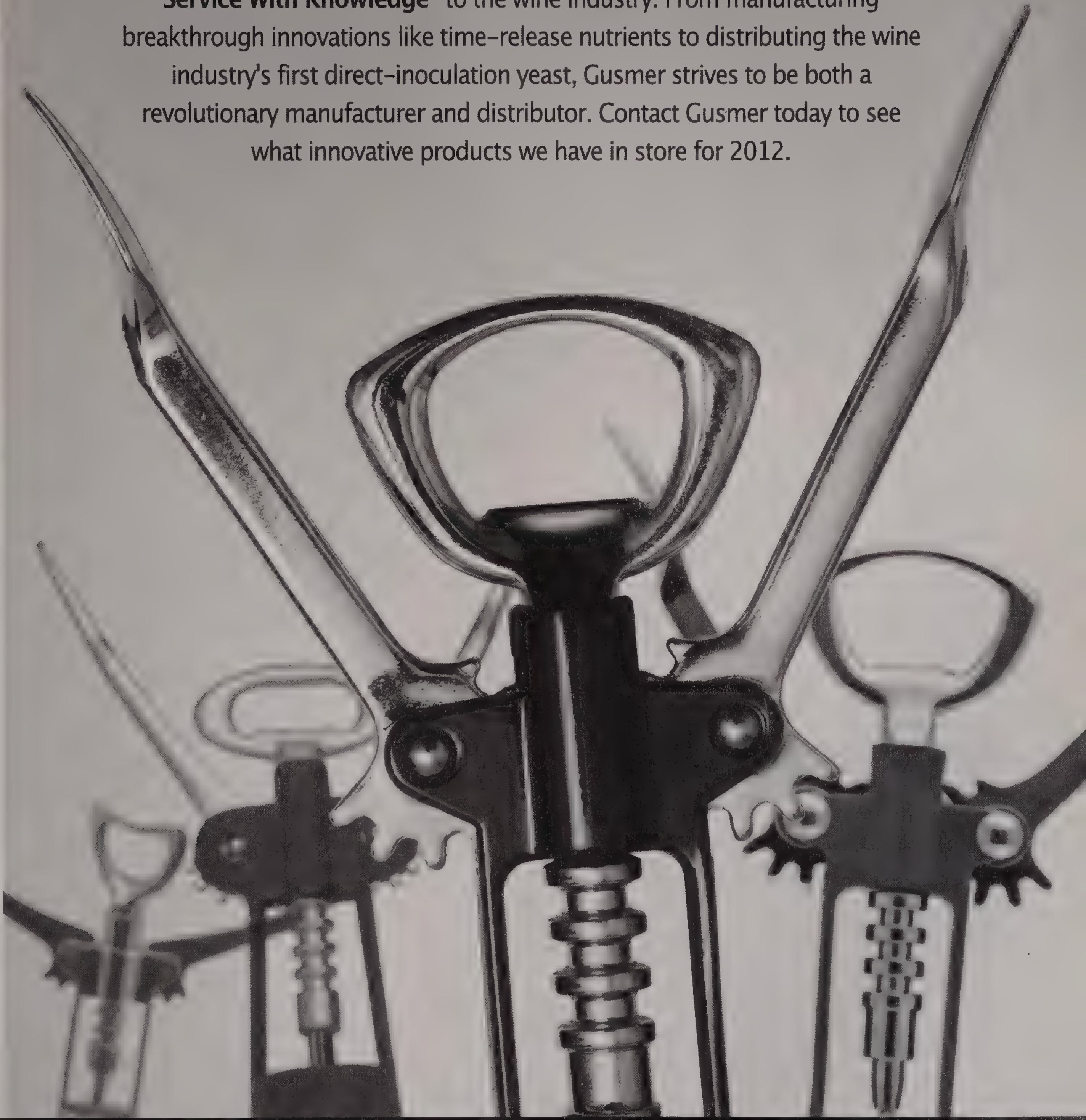

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effect on some consumers, particularly in Australia's key export market, the European Union.

EU regulations put pressure on winemakers to reduce sulfite, by lowering allowable levels. At the same time, *Brett* continued to evolve – more isolates from Australian wineries were obtained that could tolerate higher sulfite levels. Control strategies met resistance on all sides: resistance from the yeast, resistance from consumers, and resistance through regulation.

The AWRI entered this "hostile environment" with its own strategy. Drawing on its world-class expertise and technology, it set to work on tracking the yeast to find out where, why, and how it had the potential to create a *Bretty* taste and smell.

AWRI researchers found out, for example, that incomplete or "stuck" fermentations can leave enough residual sugar in wine for *Brett* to feed on. They also found out that fewer, well-timed doses of sulfites could be used against the yeast with maximum effect in some cases, spreading the word to winemakers through their network of workshops, road shows, and other extension activities.

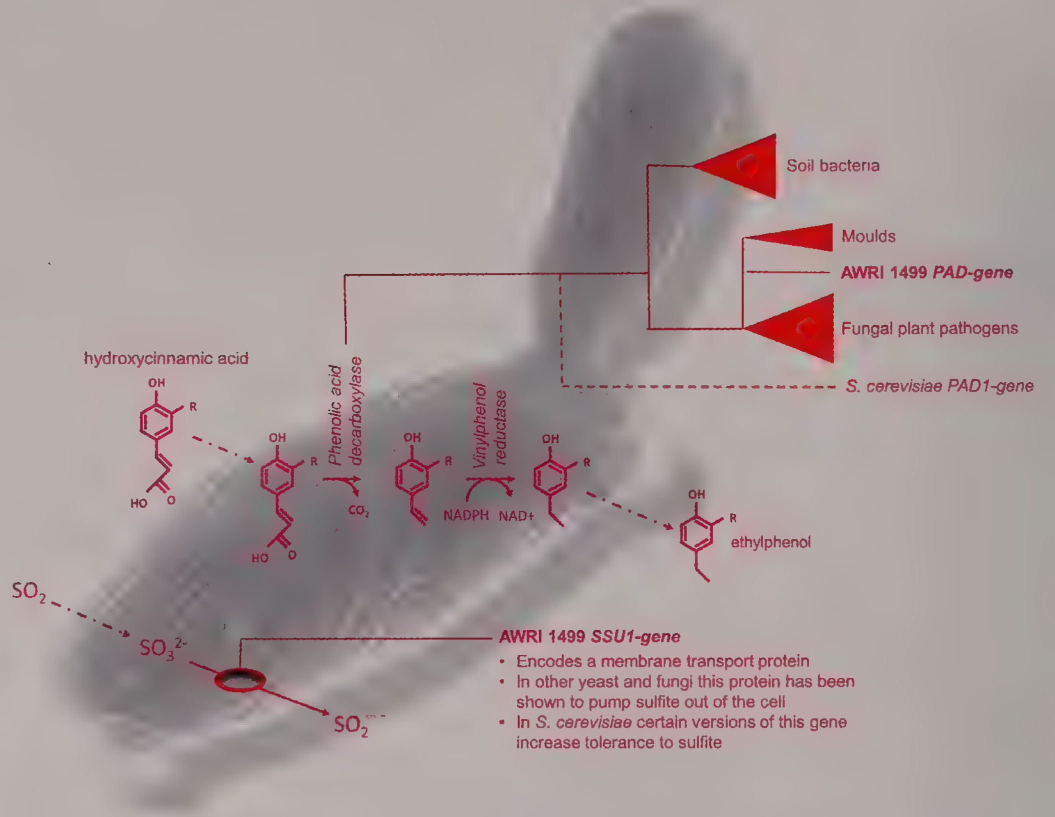

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Figure II: Gene discovery made possible by sequencing the *B. bruxellensis* genome. AWRI 1499 PAD-gene does not encode a protein with similarity to the Pad1 protein from *S. cerevisiae*, found in several other yeast and fungal species. Instead, we discovered a protein with close similarity to phenolic acid decarboxylases found in several plant pathogens and soil bacteria - this version of the protein may be more active against hydroxycinnamic acids than the *S. cerevisiae* Pad1 protein. AWRI 1499 SSU1-gene encodes a protein with similarity to sulfite pumps in several yeast and fungi. Sulfite tolerant strains of *S. cerevisiae* have higher levels of this pump present, enabling them to decrease the concentration of sulfites present inside the cell and survive in the presence of larger doses of sulfites. A similar mechanism may exist in *B. bruxellensis*.

Within eight years, the AWRI's information campaign – combined with robust research and hard work by winemakers themselves - had won a clear victory. Levels of 4-ethylphenol dropped by a dramatic 90% in Australian Cabernet Sauvignon wines (Figure I). The ratio of free to total sulfites, an indicator of effective sulfite usage, had increased, while total sulfite in finished wine had not. The AWRI's *Brett* control strategies seemed to be working; wine producers were back on track. However, the threat of another attack on Australian

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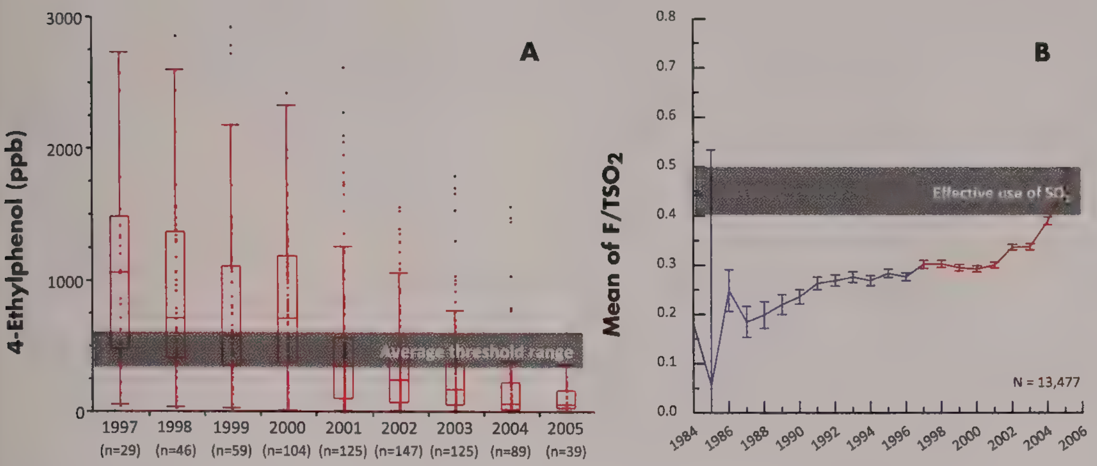

Figure I: Incidence of *Brett* in Australian Cabernet Sauvignon wines from five major regions (A), and ratio of free to total sulfites in Australian red wines (B). Overlapping periods in the two datasets are shown in red, highlighting that the dramatic decrease in 4-ethylphenol levels in Australian Cabernet Sauvignon from 2000-2005 coincided with a shift in the Free and Total SO_2 ratio from 0.3 to 0.45. Importantly, mean total sulfite concentrations did not increase during this period. Therefore, this shift was indicative of a widespread change in sulfite management strategies.

wines, mounted by new strains of *Brett*, remained a possibility.

High-tech warfare

In 2008, the Australian wine industry believed it had *Brett* under control. The risk of spoilage was much lower than before. Very few affected wines were reaching consumers.

Still, the AWRI remained cautious. Could *Brett* come back to haunt the industry? What if the dominant, sulfite-tolerant *Brettanomyces* strain in Australian wine became more tolerant to sulfites? Was this a real risk? Despite efforts to understand the biology of *Brett*, these questions could not be answered.

Overseas, research efforts were sporadic and focused upon strains that were less common in Australia. There was work to be done.

At the same time, science was entering a new era of cost-effective genomics. Driven by the goal to cheaply sequence a human genome, innovation in sequencing equipment and techniques was happening at an astonishing pace. As a result, sequencing the genomes of yeast and bacteria was within the financial and technical reach of biologists, a pursuit previously confined to a few large sequencing centers.

The outcomes have already made a positive impact. Understanding of *Saccharomyces cerevisiae*, the winemaker's favorite yeast, has advanced

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rapidly over the past few years due to several large sequencing projects. The decision was made to bring Australian strains of *Brettanomyces bruxellensis* into the genomic era, in order to "future-proof" the Australian wine industry's *Brett* control strategies.

Work began late in 2008. The AWRI sent DNA from Australia's most common *Brett* strain – AWRI 1499 – to a sequencing laboratory in the U.S. Technicians broke the DNA up into smaller pieces, and used a technique called 454-pyrosequencing to read each DNA fragment. The AWRI team was among the first in the world to access leading-edge sequencing equipment: the Roche 454 GS-FLX Titanium series. This meant greater speed and efficiency, delivering significantly more data and better value for money. Timing, in particular, proved to be crucial.

Sequencing the first yeast genome in the 1990s using more traditional methods cost considerably more time and money, in comparison. The instrument used for the AWRI's sequencing of *Brettanomyces bruxellensis* generated the same quantity of data in less than a day. But, data generation was just the start of the project.

Generating masses of sequencing data was the easiest part. In the first half of 2009, the AWRI took the raw data – all 1.5 million "sequence reads" of it – and attempted to piece the genomic jigsaw puzzle of

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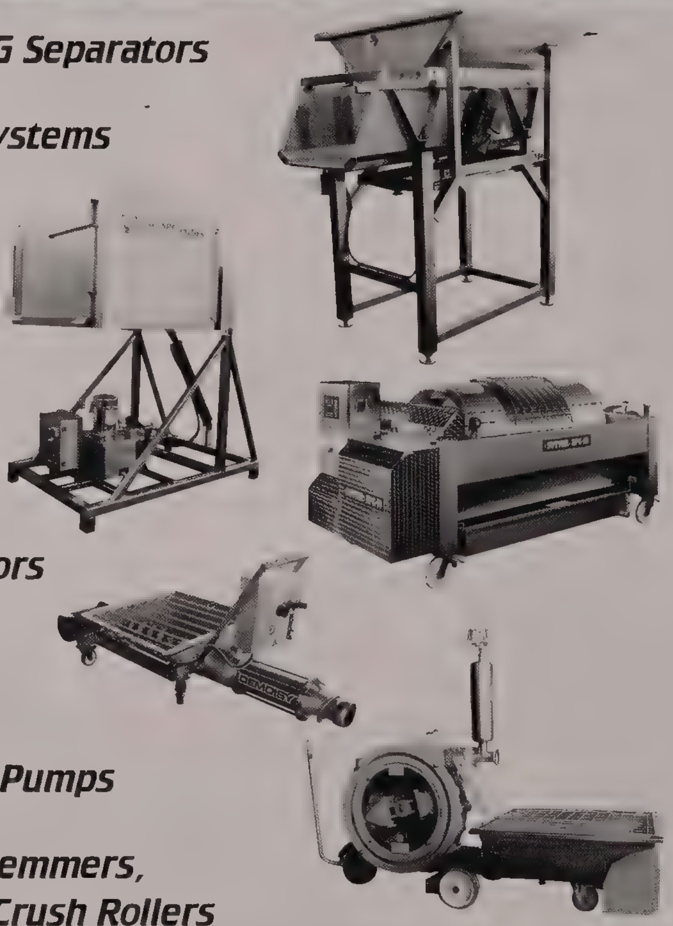

ADVANCES AGAINST *BRETT*

- Late 1990s — AWRI researchers target *Brett* by launching a research and information campaign to reduce spoilage in Australian wineries. Within eight years, through the hard work of winemakers themselves, the incidence of the compound responsible for *Bretty* characters in Australian Cabernet Sauvignon is reduced by 90%.
- 2008 — Advances in genomics make it feasible to affordably sequence the genome of wine yeast. The AWRI sets out to "future-proof" its campaign against *Brett*. Sequencing of Australia's most common *Brett* strain -- and the most resistant to sulfites — begins.
- 2009 — More than one million pieces of *Brett's* giant genomic jigsaw are pieced back together. The work takes many months and requires hours of painstaking work, supported by advances in bioinformatics technology.
- 2010 — In a breakthrough, three copies of many DNA regions are detected instead of one or two. The triploid structure may be important in enabling *Brett* to survive in wine.
- 2011 — The AWRI announces publicly that it has assembled the *Brett* genome; the achievement is welcomed as a world first. Researchers embark on the next stage of the project — developing targeted strategies for winemakers to eliminate *Brett* from their wineries.

Brettanomyces bruxellensis back together. Upgrades were necessary to the AWRI's bioinformatics server; it needed more processing power.

In August 2009, after much trial and error, 1.5 million "reads" were assembled into some 27,000 contigs (contiguous DNA sequences). This meant progress, but there was still work to do before this jigsaw puzzle would be complete.

The next stage, involving long hours over a period of almost two years, required close observation at a computer screen to decide if a stretch of DNA sequence was an "edge piece." If so, the question was where exactly in a pile of many thousands of similar-looking edge pieces it belonged. When a match was found, computer software was used to reassemble the two pieces. Gradually and painstakingly, the AWRI worked towards the middle of the puzzle.

Late in 2010 there was a "light bulb moment." There was a reason why the puzzle was so hard to put together: there were more pieces than there should be. The genome of the *Brett* strain under investigation did not have two copies of each DNA region - as is the case for many genomes, including humans. There appeared to be three.

While triploid genomes do occur amongst yeast and plant species, most yeast sequencing projects have been performed using strains that have only one copy of each DNA region, to make the assembly process simpler. Without the data provided by the newly-developed Titanium series sequencing technology, the task of assembling *Brett*'s triploid genome may have proven impossible.

By June 2011, most of the pieces had been put back together, with 324 assembled contigs in 99 "scaffolds." The genome assembly was ready to be explored. AWRI researchers used bioinformatics tools to search the DNA sequence for genes, and compared them with databases containing all genes known to science. Drawing a blueprint for *Brettanomyces bruxellensis* had become a reality, with the potential to transform the way that winemakers engage with the "enemy."

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Advancing the frontline

Armed with their discoveries so far, AWRI researchers are now moving into the next stage of their *Brett* genomics research project. This next phase continues to draw on the cross-disciplinary capability of the AWRI: the early victories over *Brett* in the 1990s were the result of extension to and engagement with winemakers in the trenches by the AWRI's Industry Development and Support Group; the sequencing project was undertaken by the Biosciences Research Team.

While key issues are still under investigation, AWRI researchers have already used this resource to make important discoveries. Significantly, one of the genes responsible for sulfite tolerance has been identified (Figure 2).

Genes involved in the manufacture of 4-ethylphenol have also been spotted – providing new targets in the battle against *Brett*'s unsavory characters. The genetic blueprint is also providing clues as to where the yeast may be found in the winery. This may provide winemakers with another strategy to eliminate the enemy from their territory.

Above all, the sequencing project demonstrates the importance of combining real-world problems with world-class expertise. The focus of the AWRI's research remains the challenges faced by Australian grape and wine producers as they seek to compete globally, in a testing environment. Advancing the frontline against *Brett* is just one way that the AWRI is providing industry with the logistics, equipment and know-how to secure an upper hand. ■

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WINNING AT Snakes and Ladders

BY Chris Curtin, Anthony Borneman, Paul Chambers, and Sakkie Pretorius, The Australian Wine Research Institute, Adelaide, SA, Australia

Winemaking is not unlike a game of "Snakes and Ladders" (Figure 1). There are long "ladders" which bring you closer to your goal, built on the backs of "good" yeast such as *Saccharomyces cerevisiae*, also known as the winemaker's bug. Under the right conditions this yeast creates, accumulates, and tolerates alcohol, converting sweet sugary, low-flavored grape must into distinctive, highly flavored wine and enhancing the sensory characters of the end-product in the process.

There are also long "snakes," which hamper your progress to your goal, such as *Dekkera bruxellensis,* also known as *Brettanomyces.* "Brett" – as this troublesome microbe is commonly known – is a spoilage yeast with the capacity to turn the most refined wines into unsavoury drinks with characters described as "barnyard" and "medicinal." Backed by sound science, Australian winemakers have succeeded in bringing Brett under control – for now.

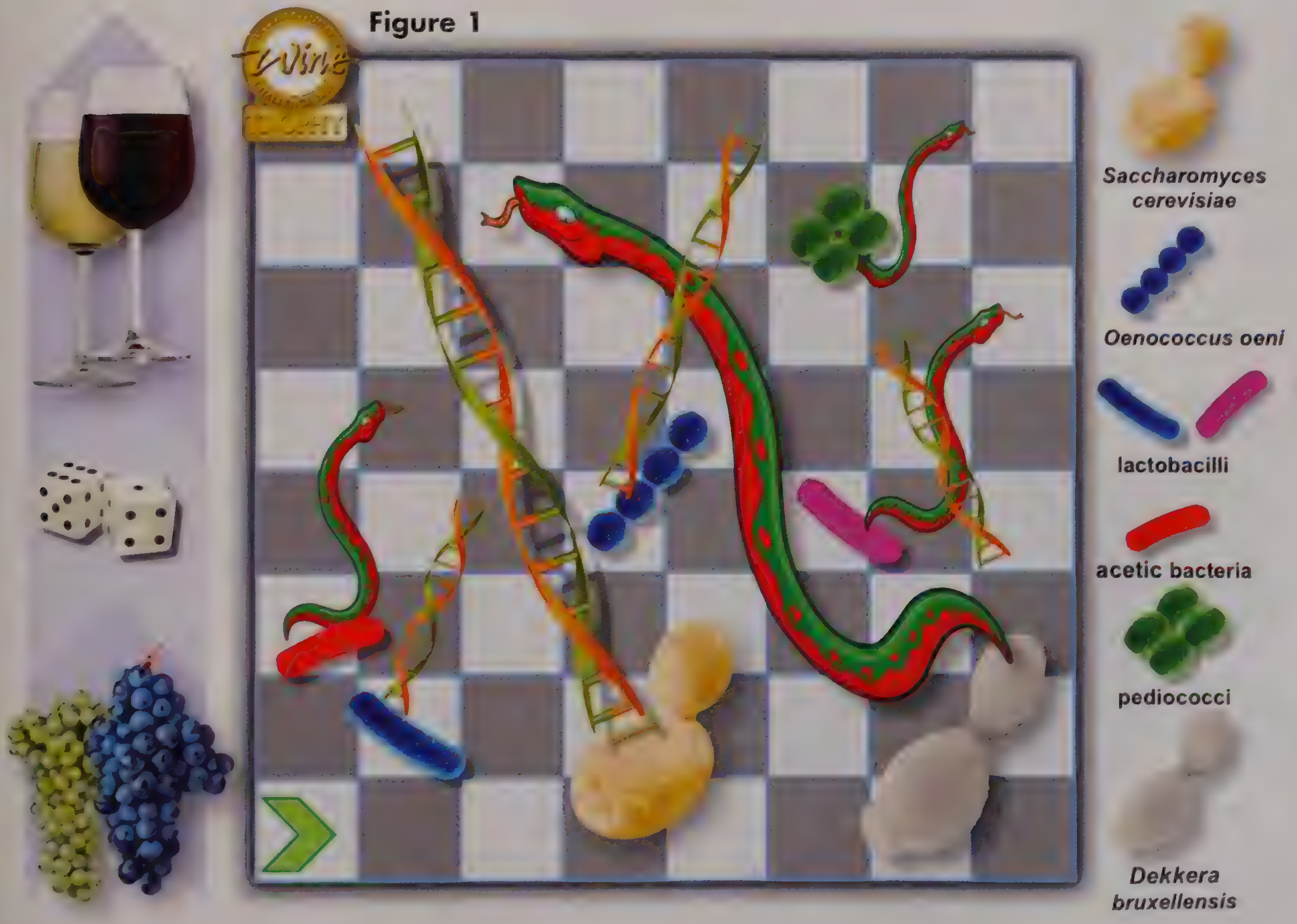
The Australian Wine Research Institute (AWRI) is working with winemakers to stack the dice in their favor. They are also working on the design of the game to eliminate snakes and add more ladders to help winemakers achieve their goal more quickly and efficiently, with fewer setbacks along the way.

Securing the longest ladder

One "ladder" that improves a winemaker's luck is *Saccharomyces cerevisiae.* As a "wild" yeast, given time, this bug finds its way into "natural" or "spontaneous" fermentations, transforming grape juice into wine. The problem for winemakers is that the process can be unpredictable. Un-inoculated ferments remain a game of chance: sometimes the outcome is outstanding, sometimes it is disastrous.

Spontaneous fermentation leaves

Figure 1



wine exposed to "bad" or unwanted bugs. As winemakers weave their way up the board, hoping that *Saccharomyces cerevisiae* will work its magic, snakes are lurking. They won't necessarily destroy the end-product, but they can undermine its quality with unsavoury tastes and smells. A long, strong ladder early on in the game helps bypass trouble and gets you to your goal.

Inoculating with the right wine yeast early on has been shown to be a reliable way to kick-start fermentation. But researchers at the AWRI are going further in their search for reliable fermentations. They are applying new genomics technologies and systematic approaches to identify the best, and develop improved, strains of *Saccharomyces cerevisiae*; they want winemakers to have the longest, toughest, and most trustworthy ladders.

These strains – now commercially and widely available to the Australian wine sector – produce "robust"' fermentations with the ability to keep snakes, such as hydrogen sulfide production and "bottle stink" at bay. Their discovery and, in some cases, development by AWRI researchers was the result of painstaking work, where strains of wine yeast were compared, genetically, with brewers' and bakers' yeasts. As a result, scientists are working out which genes are responsible for fermentation performance and the formation of flavor-active compounds in wine, and using this knowledge to assess which strains are best.

Improving your chances

Although appropriate choice and use of *Saccharomyces cerevisiae* might be the longest ladder on the board, *Oenococcus oeni* also offers a boost. Inoculation with *Oenococcus oeni* is more likely to produce reliable malolactic fermentation (MLF); it is a critical "ladder" – next to careful use of wine yeast – that helps to bypass the longest snake on the board. This is a huge step forward and the direct result of ongoing research. Genomics research is also helping winemakers to manage MLF, and keep other "snakes" at bay.

There are other "ladders" that start from square one – sulfite management is one, keeping various organisms, including *Brett*, in check, and general hygiene throughout the winery is another, avoiding the snakes that have the potential to lurk in forgotten corners and hidden places. ■

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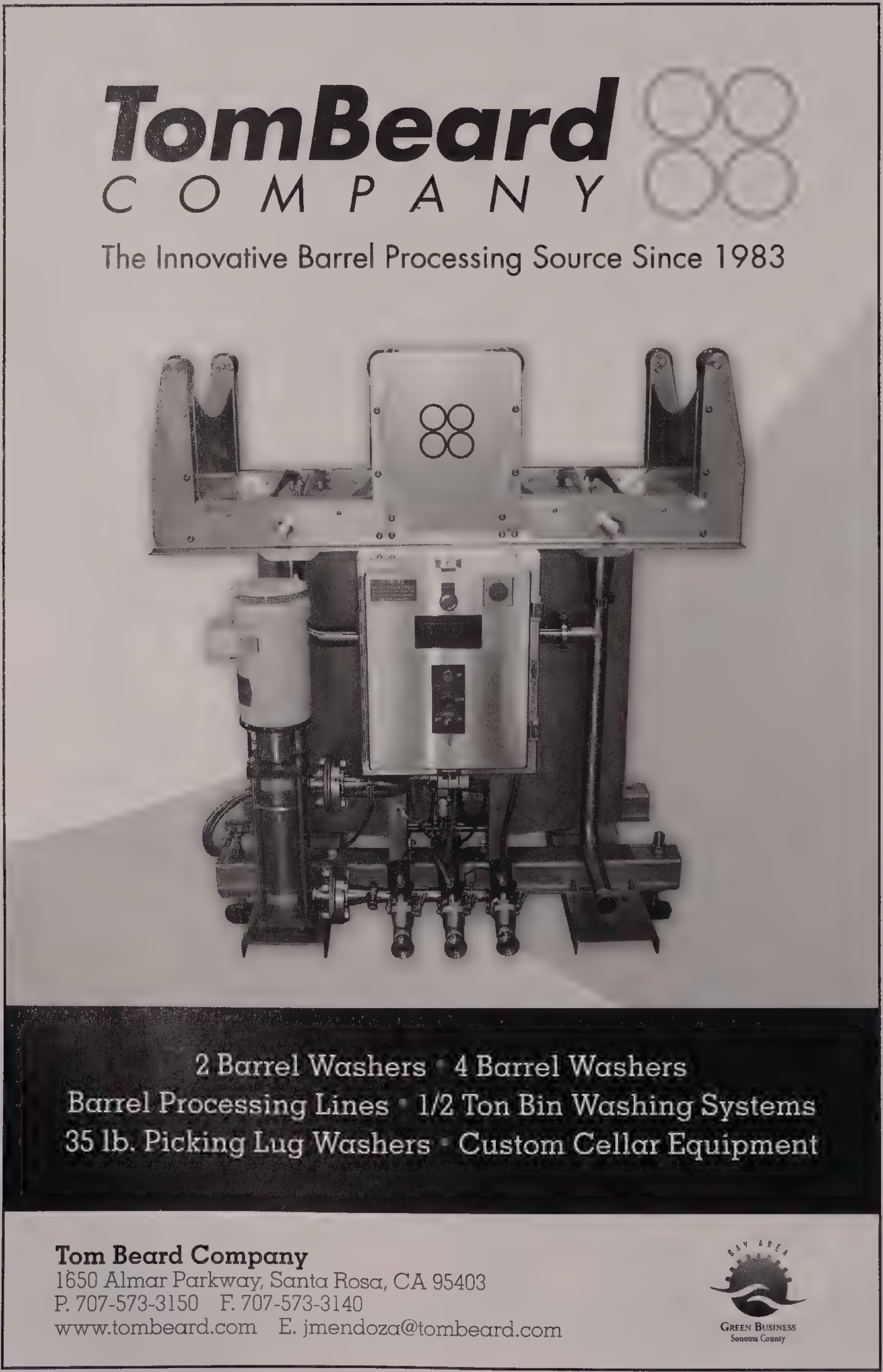
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Oenococcus oeni and Lactobacillus plantarum

Effects of MLF on red wine aroma and chemical properties

BY Eveline Bartowsky, Peter Costello, Leigh Francis, and Brooke Travis,
The Australian Wine Research Institute
Sibylle Krieger-Weber, Lallemand Germany, **Andrew Markides,** Lallemand Australia

Wine color is important, but the aroma and flavor leave the greatest impression of a glass of wine. Compounds that contribute to the sensory experience of wine originate from the grape and microbial metabolism during winemaking. Yeasts are responsible for the conversion of grape sugars to alcohol and play a major role in the aroma and flavor of wine.

However, bacteria are not only responsible for malolactic fermentation (MLF), they contribute to the final sensory experience of wine.[7] MLF is an important step of the vinification process of red wines, several white wine styles, and sparkling base wines. The process of MLF is well understood, and its main roles are to reduce wine acidity and improve microbial stability.

While numerous species of the lactic acid bacteria family are able to conduct MLF, Oenococcus oeni is the preferred species because of its ability to tolerate the high acidity and ethanol concentrations, sulfur dioxide and the low nutrient content of wine. Lactobacillus and Pediococcus species are also able to conduct MLF, but have generally been considered undesirable in wine.

In recent years, Lb. plantarum has been reconsidered as an option for MLF.[1] In addition to reducing wine acidity and improving microbial stability, MLF also offers the opportunity to modify the sensory properties of a wine. During MLF, O. oeni metabolism modifies the chemical composition of wine and this translates into changes in the appearance, aroma, and palate of the wine.[37]

O. oeni is able to interact with a wide range of chemical compounds present in wine, including carbohydrates, polyols, proteins, amino acids, phenolics, organic acids, and glycosides.[2] Many of these alterations in wine composition are strain-dependent. However, winemaking techniques can also be used to manipulate wine composition.

Reduction in wine acidity is the crucial feature of MLF, due to the degradation of malic acid resulting in a slight increase of wine pH by 0.1 to 0.3 pH units. This is sensorially observed as a softening of the wine. Medium- to full-bodied red wines are often described as having blackcurrant, dark cherry, raspberry, and plum aromas.[4] A challenge faced by winemakers is to accentuate the fruitiness of red wine and to keep green and herbaceous characters at bay.

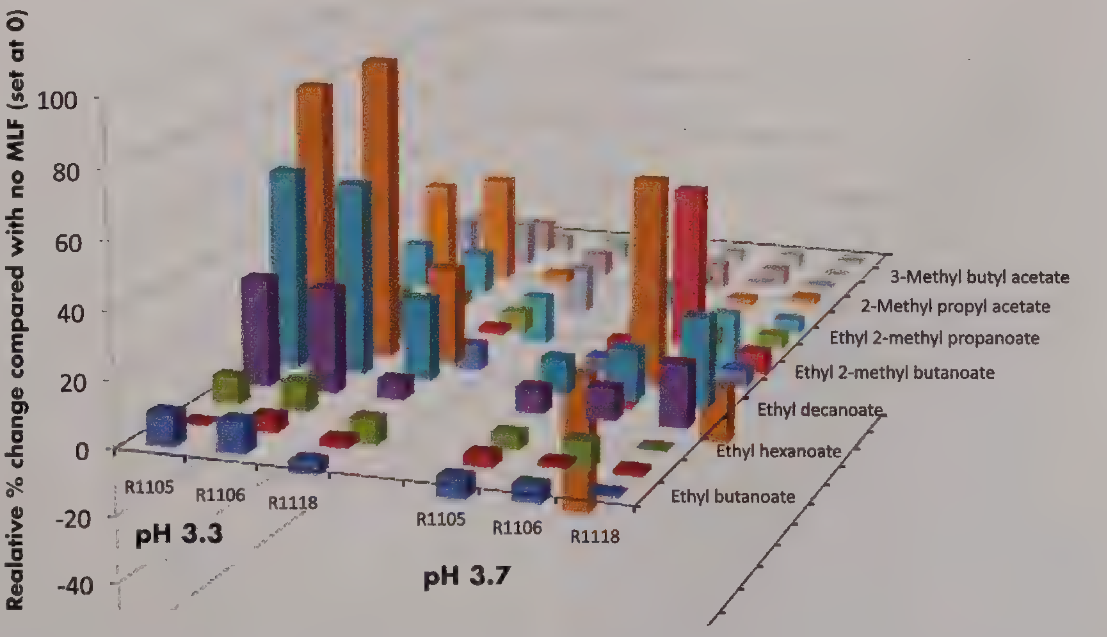

Figure 1: Volatile fermentation-derived compounds in Cabernet Sauvignon wines (Clare Valley, South Australia, 2006; pre-MLF pH at 3.3 or 3.7) after MLF by three *Oenococcus oeni* strains. Changes in concentration are shown as relative percentage change to no MLF (set at 0).

This work explores the influence of Oenococcus oeni and Lactobacillus plantarum on sensory characteristics through changes in volatile compounds produced during bacterial growth.

In a trial done by the AWRI (Australia), Cabernet Sauvignon grapes were harvested at commercial maturity, and fermented to dryness with Saccharomyces cerevisiae yeast in 2006, 2008, and 2009 from South Australian viticultural regions – Clare Valley, Langhorne Creek, Padthaway, and Adelaide Hills. Malolactic fermentation was conducted in triplicate with seven Oenococcus oeni strains – Alpha, Lalvin 31, 49A1, PN4, VP41, Beta, and Elios 1.

In 2010, Cabernet Sauvignon grapes from Clare Valley and Coonawarra were similarly vinified for Lactobacillus plantarum trials. Following MLF, sulfur dioxide was added, the wine was filtered and bottled into 375 mL screw-capped glass bottles, and stored at 15°C. If required, wine pH was adjusted to either 3.3 or 3.7.

Malic acid was determined enzymatically and MLF was deemed complete at approximately <0.1 g/L malic acid. Volatile compounds were deter-

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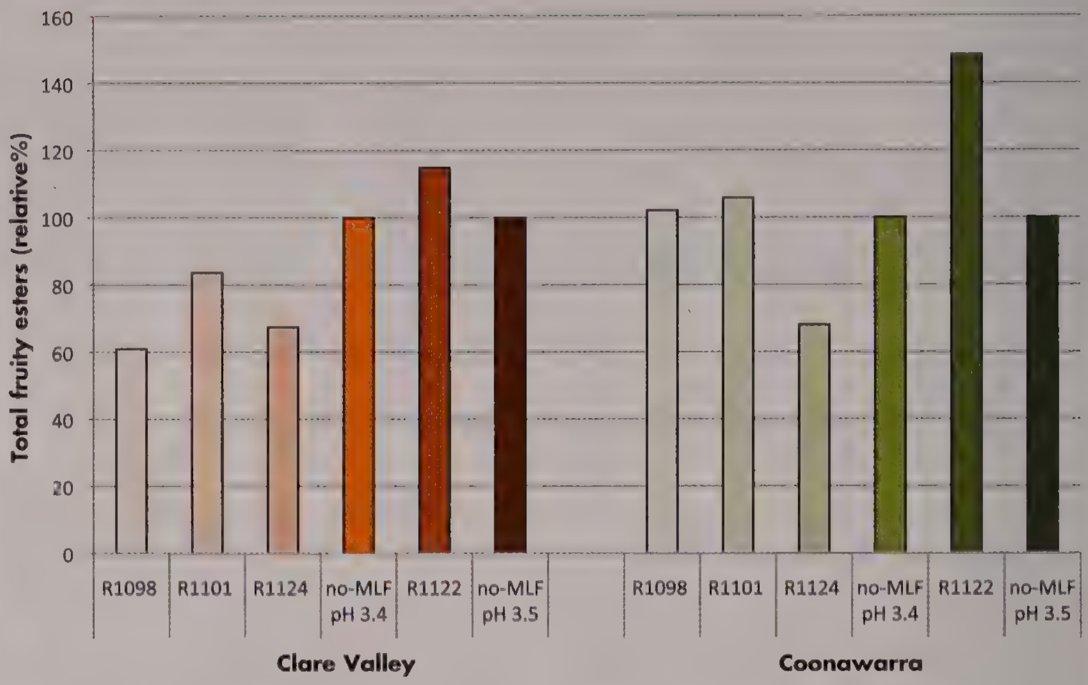

Figure 2: Total fruity esters, relative to no MLF, in Cabernet Sauvignon after MLF was conducted by three *Oenococcus oeni* strains (Alpha, Lalvin 31, PN4) and *Lactobacillus plantarum* strain (R1122). Fruit was sourced from Clare Valley and Coonawarra viticultural regions, 2010.

mined by gas chromatography/mass spectrometry (GC/MS) using procedures based on those described by Siebert et al.6

Results and Discussion:

pH

Figure 1 shows the effect of pH upon the volatile aromatic compounds of Cabernet Sauvignon in relation to wine which was not inoculated with Oenococcus oeni. Lower pH favors the production of volatile compounds derived from bacterial growth, especially the C4 – C8 ethyl esters.

The pre-MLF wine pH was an important factor in sensory differences between the wines, particularly in fruit-related descriptors. Wines that completed MLF at pH 3.3 were described as having more fruity characters and higher raspberry aroma, especially with Oenococcus oeni strains VP41 and Beta.

Ethyl acetate concentrations increase regardless of the Oenococcus oeni strain used, but to a different extent. Several compounds show increases or decreases dependent upon the Oenococcus oeni strain (2-methylpropyl acetate, ethyl butanoate, and ethyl propionate).

The total red fruit ester concentration was much higher in wines with a starting pH of 3.3 as compared to non-MLF wine. At a pre-MLF wine pH of 3.7, the concentration of total red fruit esters decreased relative to the non-MLF wines. Oenococcus oeni strains VP41 and Beta both had elevated concentrations of volatile fermentation-derived compounds, particularly those which have been reported to contribute to red fruit character.3,5

Multiple viticultural areas

Figure 3 graphically illustrates esters contributing to fruity characters as the result of MLF conducted by four strains of Oenococcus oeni in wines from four viticultural regions.

The three Oenococcus oeni strains, VP41, Beta, and Elios 1 produced fruit-related esters in a similar mode in all four Cabernet Sauvignon wines, with red berry, blackberry, and total fruity esters showing the lowest concentrations in Langhorne Creek wines.

Variations in the concentration of the esters produced most likely reflect differences in precursor concentrations. Generally, wines which received bacterial inoculation exhibited higher final ester concentrations.

Lactobacillus plantarum

Three strains of Oenococcus oeni, Alpha, Lalvin 31, and PN4, plus V22 (a strain of Lactobacillus plantarum), were used to inoculate wines from

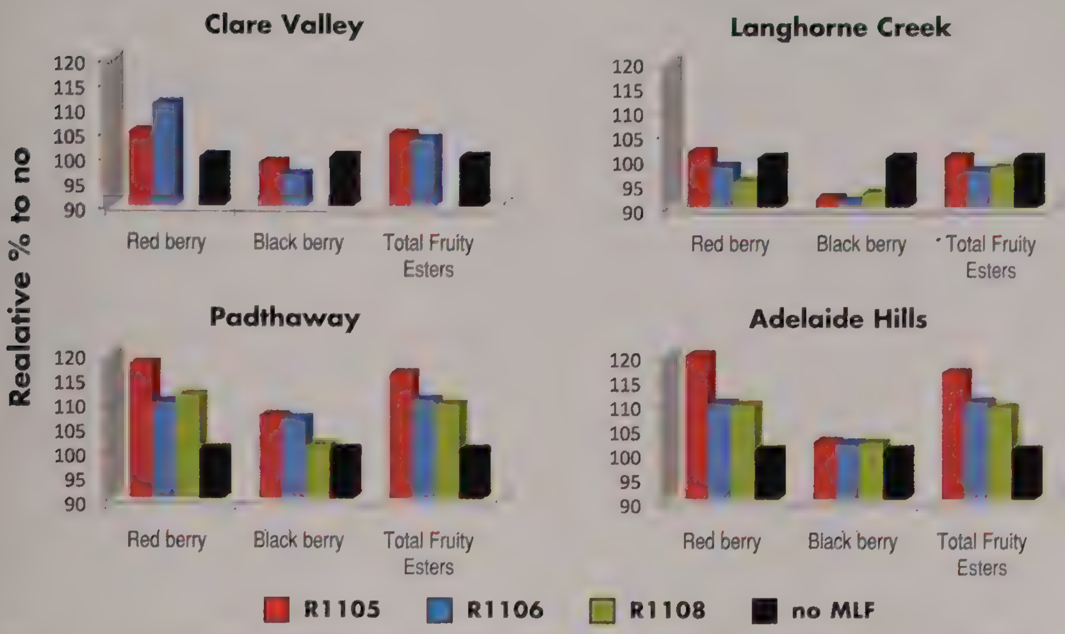

Figure 3: Sum of esters contributing to fruity characters (red berry, blackberry, total fruity esters) expressed as relative percentage to no MLF (100%), in Cabernet Sauvignon from four South Australian viticultural regions (vintage 2008), after MLF induced by three *Oenococcus oeni* strains.

the Clare Valley and Coonawarra. All Coonawarra wines completed MLF within 20 days, and Clare Valley wines completed MLF between 35 to 40 days. The Lactobacillus plantarum strain produced sound wines with indications of an increase in fruity aroma and flavor characters.

Conclusions

There was generally an increase in total fruity berry esters in wines made from Cabernet Sauvignon inoculated with Oenococcus oeni. Positive changes in ester concentration following MLF are consistently observed. Increases in ester concentration are reflected in enhanced fruity and berry aromas.

In Cabernet Sauvignon, MLF conducted at lower pH resulted in greater increases in total fruity esters, as compared to MLF conducted at higher pH. All malolactic bacterial strains influenced the fruity characters of wine.

The opportunity to use MLF to alter the sensory properties of wine is increasingly becoming a pertinent component influencing the winemaker's decision to conduct MLF in red and white wines. Bacterial metabolism during MLF in wine influences a vast pool of secondary metabolites, including organic acids, diacetyl, fermentation-derived volatile compounds (esters, acetates, acids and higher alcohols), and oak compounds (when wood is used).

These studies highlight the importance of O. oeni strain selection, and the wine conditions under which MLF is conducted, to enhance the fruity and berry characters of red wine. MLF can be a powerful winemaking tool, not only to reduce wine acidity, but to positively influence the aroma and flavor profile of the wine. ■

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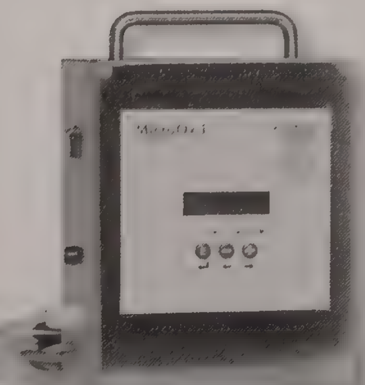
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Many varieties to be presented are either well-suited for winemaking in warm climates (Winkler Region III or higher) or where freezing temperatures may kill Vinifera vines. An overview of breeding programs for new varieties will be presented and a panel discussion of industry members on difficulties to introduce new wine varieties to various marketing channels: on-premise, three-tier distribution, and direct to consumer sales. A regional tasting including countries where speakers are from will complete the symposium.

Organizing Committee: Glenn McGourty, University of California Cooperative Extension, Mendocino County, James Wolpert, University of California, Davis.

Topics and Speakers are:

Research experiences at UC Kearney with Alternative Varieties, James Wolpert; Wine Varieties of Greece, Haroula Spinthiroupola; Wine Varieties of Portugal, Richard Mayson; Breeding programs from around the world and their likely contribution, Andrew Walker (UC Davis); Wine Varieties of Sicily, Antonio "Nino" Pisciotta; Experiences growing wine grapes in cold winter regions, Paolo Sabbatini (Michigan State Univ.); Challenges to introduce new varieties to the trade, Nick Dokoozlian (E&J Gallo), Randall Grahm (Bonny Doon Winery), Earl Jones (Abacela Winery, OR).

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Brett

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GENIE ON A DIET–

Snapshot of shrinking wine bottle weights, tiny carbon footprints

BY **Dr. Christian Butzke,** Professor of Enology, Purdue University

Various weights of 750ml bottles: From left: 11.64-oz/330 grams, 16-oz/453.59 grams, 24.692-oz/700 grams. Photos courtesey of O-I

Global warming and GMOs

There was a time when the term "carbon footprint" only evoked images of my Odor-Eaters. Not anymore! According to the *Harpers Wine & Spirits Trade Review* and in a deal brokered by the organization (that is always good for a hearty laugh), the International Organization of Vine and Wine (OIV, pronounced Oy vey) — "wine producers, suppliers, logistics firms, and retailers — will be able to rate their environmental performance using a standardized method for calculating the industry's carbon dioxide and greenhouse gas emissions. The Greenhouse Gas Accounting Protocol will allow firms to benchmark the carbon footprint of their products."

Don't get me wrong — I am deeply concerned about our industry and global warming, though I think most of the hot gas is emitted by the legions of wine bloggers rather than the burning of fracked natural gas. In fact, I spoke at the very first international symposium on wine and global warming in Spain in 2006.

However, I agree with 2011 American Society of Enology & Viticulture Merit Award winner Jerry Lohr, that the main threat to our industry over the next two decades will come from the potential for PD-resistant GMO vines from China and its already 1 million+ acres of vineyards. No worries, though — our industry will probably be saved just in time by an insufferable wine video blogger (Gary Vaynerchuk) from New Jersey!

Wine competition statistics

Over the past five years, I have had the annual pleasure of being the chair and chief judge of the Indy International Wine Competition (www.indyinternational.org), arguably the largest independent and scientifically organized wine judging in the Americas. Thanks to those wineries who enter, its entry fees also support my graduate students at Purdue. More than 50 distinguished judges (see photo) see thousands of wines from roughly 15 countries and 40+ states every year, a magnificent snap-

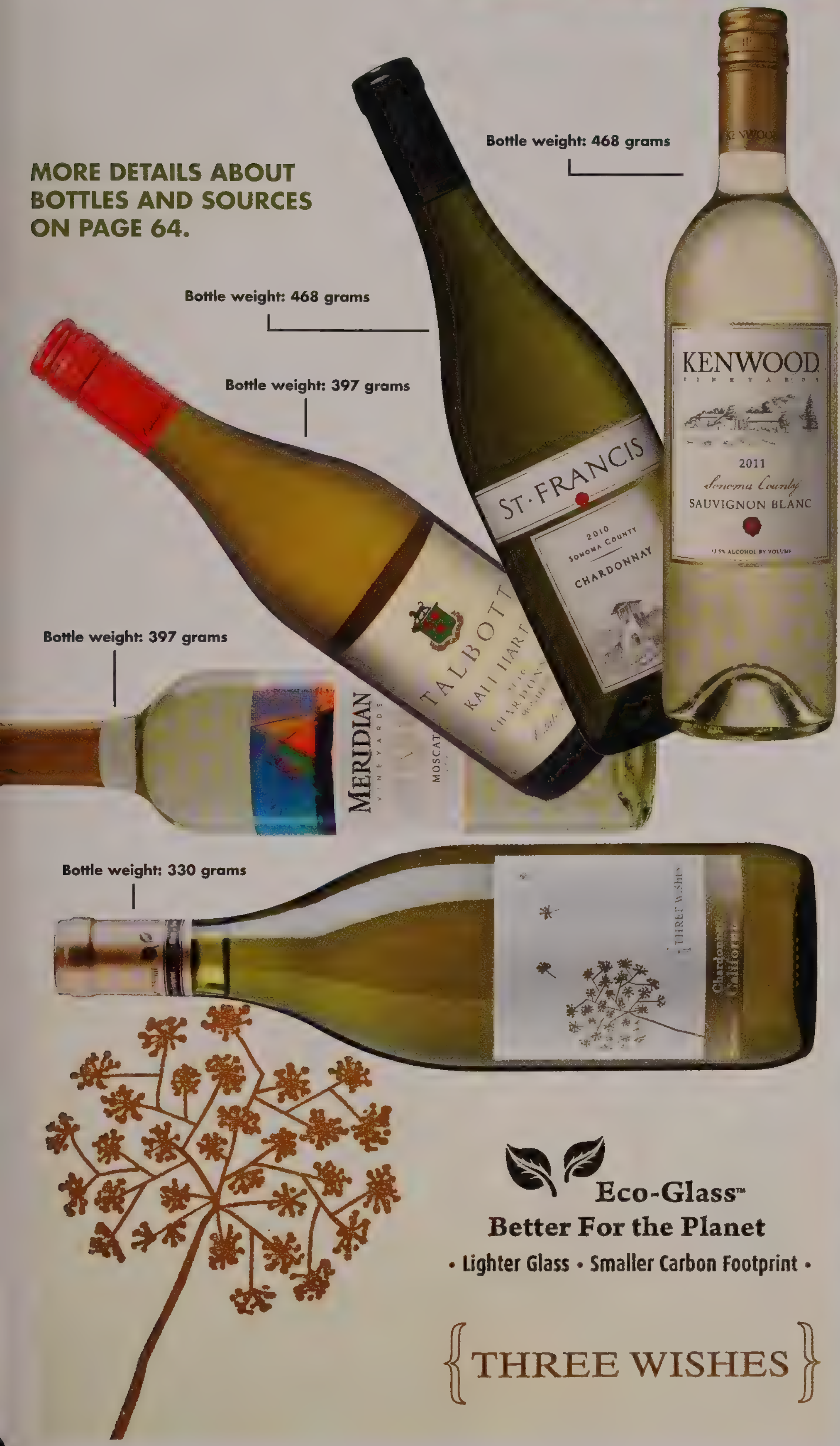
Bottle weight: 454 grams

Bottle weight: 468 grams

Bottle weight: 392 grams

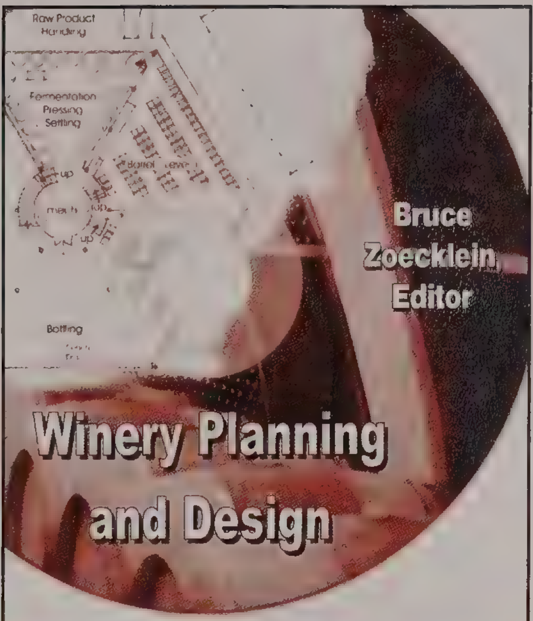
Bottle weight: 600grams

MORE DETAILS ABOUT BOTTLES AND SOURCES ON PAGE 64.



shot of products at all price points and from all company sizes. From Barolo to Norton, from Chablis to Traminette, we have seen and tasted it all!

A couple of years ago, I turned from


Bruce Zoecklein, Editor
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This CD is exclusively available at practicalwinery.com for $120.

BOTTLE CAPTIONS:

Rodney Strong Vineyards (Sonoma County, CA), reduced bottle weights 22% throughout their entire Sonoma County product line with 454-gram VITRO Packaging bottles.

Tinhorn Creek Vineyards (Oliver, BC, Canada), uses 468-gram ECO Series™ Inspiration bottles purchased through TricorBraun WinePak for 85% of their production (15% weight reduction).

SeaGlass Wine Company (St. Helena, CA), uses clear, claret 392-gram bottles for Sauvignon Blanc, and blue, hock bottles for Riesling made by O-I, sold by Cal Glass Company, that is considered "light weight" according to the Liquor Control Board of Ontario (LCBO).

Edge Cabernet Sauvignon (Napa, CA) in a 600-gram Italian Imperiale Alta bottle from Global Package with an elegant taper, fanciful top, and slightly taller height than "standard," that makes it more regal, with a moderate punt.

Three Wishes (Wine Group, CA) wines, distributed by Whole Foods markets, in Verallia North America 312-gram ECO Series™ Revolution bottles.

Kenwood Vineyards (Sonoma, CA), 2011 Sauvignon Blanc in a 468-gram Verallia ECO Series™ Inspiration Claret Stelvin bottle (16% weight reduction), distributed by TricorBraun WinePak.

St Francis Winery & Vineyards uses 468-gram Verallia ECO Series™ Inspiration Burgundy bottles for Sonoma County wines, (21% weight reduction), and 454-gram Inspiration Tapered Claret bottles (18% weight reduction) purchased through TricorBraun WinePak. Due to lighter weight, 21% more bottles can be loaded in a truck, reducing greenhouse gases and transportation impact by 18%.

Talbott Vineyards (Gonzales, CA), uses 397-gram ECO Series™ Evolution Burgundy bottles for Monterey County Chardonnay, and 468-gram full punt Inspiration Burgundy for Pinot Noir distributed by TricorBraun WinePak.

Meridian Vineyards (Treasury Wine Estates, California), is one of many of TWE brands using 397-gram Verallia North America ECO Series™ Evolution bottles; achieving a weight reduction of 26% over the past five years.

the cork industry's villain to poster boy for suggesting that, based on the insignificant number of corked wine called by my judges, the issue of 2,4,6-trichloroanisole (TCA) is now a bigger problem with bagged carrots than bottled wine. Over the years, my students have diligently counted closures and bottles, so I can share some anonymous but insightful statistical data with you that otherwise are hard or expensive to come by.

After each of the more than 250 wine flights, members of the 2011 Indy *Pit Cru* (thank you to Paul Cohen, Katie Study, Tiffany Lehman, Chris Helderman, and Tianlin Xu) weighed 1,549 empty table wine bottles of different labels, a significant portion of the total commercial entries. The lightest 750 mL bottle came in at 314 grams, and the biggest at 886 grams, almost three times as heavy. That is still a far cry from the 2001 Oakville Cabernet that I bottled in good old three-pounders from Italy (actually weighing in at 1,200 grams).

Given the average density of table wine, which depends mostly on alcohol and R.S. concentration, bottle fill height variability, etc., the actual wine in a *fifth* (of a gallon bottle) weighs somewhere between 710 (let us assume a dry white Port) and 780 grams (for an Eiswein-style dessert wine). This means that a full bottle of lightweight glass can weigh less than an empty bottle of show-off strength.

Over the past few years, winemakers and marketers have reigned in on the phallic proportions of the heaviest of bottles. Yet, we wanted to see what the statistical averages, means, and modes of current industry practices truly are. Here are the results from these more than 1,500 individual commercial wine bottles:

For reference, the mean is the arithmetic average of all bottle weights, i.e. the weight of all bottles combined divided by the number of bottles. The median is the value compared against which 50% of the individual bottles weighed more, while the other 774 weighed less. The mode is the most frequently observed bottle weight.

Figure 1 shows the mass distribution for 2011 Indy entries, so you can

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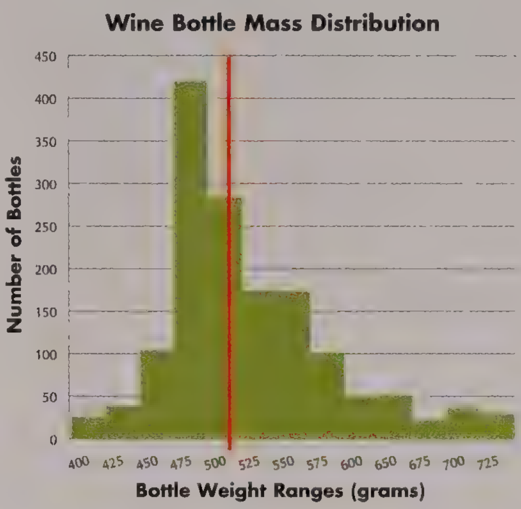
see where your bottling operation stands. Indeed, few winemakers these days chose bottles beyond the two-pound range, though few also take advantage of lightweight glass that can now weigh as little as 300 grams.

Environmental impact

Our entries do span multiple vintages and years of bottling, hence not precisely what is used in the bottling rooms this month. I intend to take similar snapshots of bottle weight distributions over the next few years to see if wine producers are becoming more carbon footprint-conscious. Not included in this statistic is the enormous variety of different bottle molds and glass colors. This makes reuse of bottles grossly impractical, and even simple yet energy-consuming recycling challenging.

Undoubtedly, and even as the global wine industry markets itself as greener and more sustainable than ever before, lightweight bottles come with the same prejudice of a *cheap* look and feel that screw cap closures endured years ago. Plus there are many examples of consumer products out on the market where the packaging is vastly more expensive than the content: perfume, vodka, and energy drinks, to name a few.

Figure 1: Weight distribution frequency of 1,549 bottles (2011 data).



Fair enough though, a wine collector may rightfully expect a wine that was made from, let us say Andy B.'s $50k/ton Oakville grapes, and thus contains more than $60 worth of fermented grape juice, per bottle in a more substantial feeling package (even though it would not impact its inherent quality or ageability).

If we come back to the idea that winemakers benchmark the carbon footprint of their products, we can apply some of the published calculators to estimate the environmental impact between shipping wine in 314-gram bottles compared to 886-gram bottles.

Carbon dioxide emission factors for wine shipments are expressed in terms of grams of CO_2 released per metric ton of cargo per mile transported. The emissions factor for non-refrigerated trucking is 252 g/t/mile (Greenhouse Gas Protocol Initiative, retrieved from www.ghgprotocol.org).

Let us assume you load a standard trailer with 14 pallets of wine at 64

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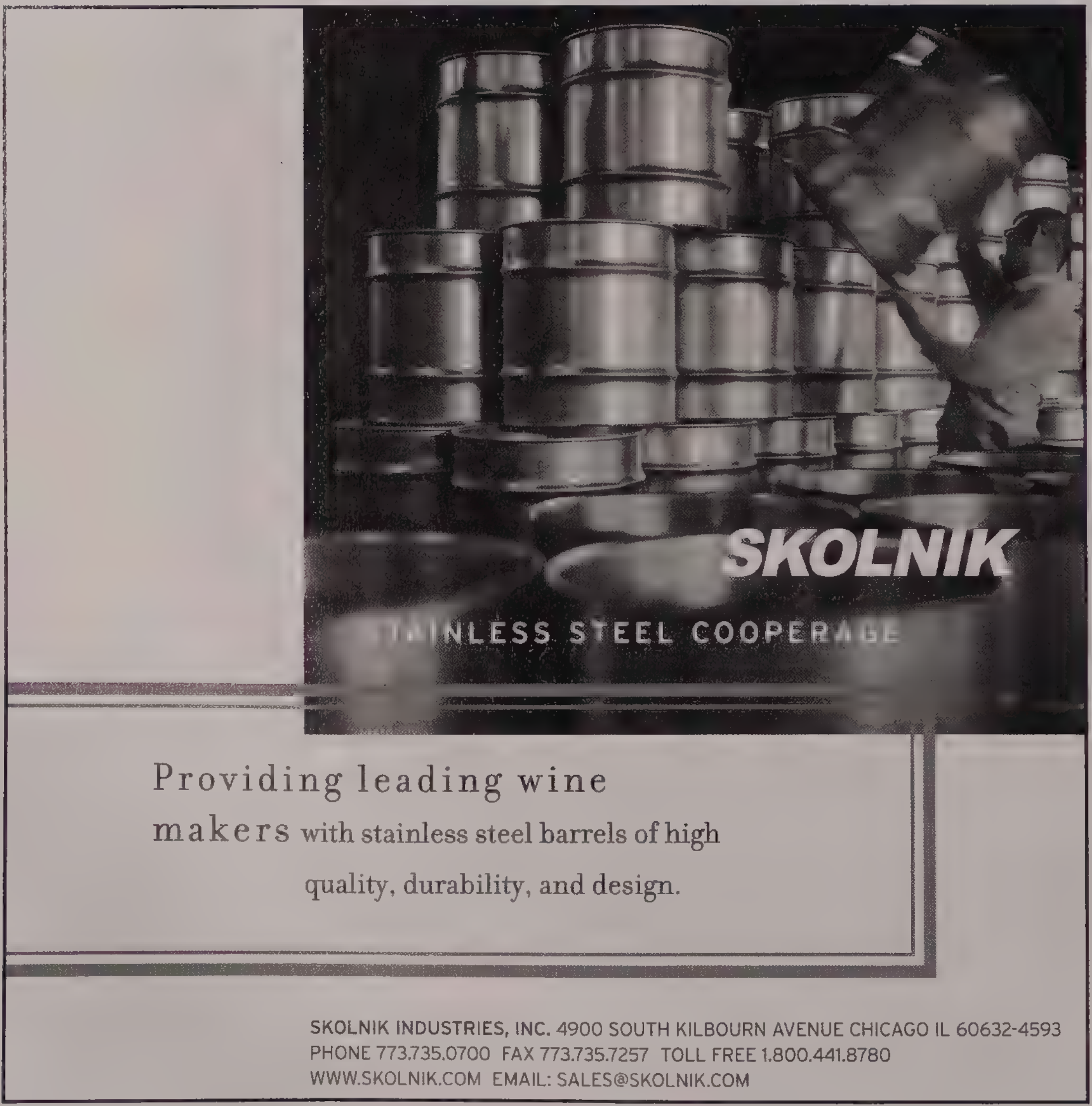
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cases each. At an average wine density (750g/bottle), and neglecting box, closure, and pallet weights, that load would weigh 25,200 lbs using the lightest bottle and 38,700 lbs using the heaviest. That is a difference of almost seven tons or 54%.

Theoretically, and assuming a shipment from a warehouse in Lodi, CA to New York City, the lighter truck would generate 18,100 lbs of CO_2. The heavier load would produce 27,900 lbs. Practically though, these differences may be less relevant. One cannot fit more pallets given the trailer's footprint, and to pack pallets six-high would be hard for the bottling crew to do if they lift and stack by hand. Consequently, the truck would drive away with a lighter load rather than with more wine per shipment, and the energy savings in increased mpg would be much less significant.

Carbon footprint vs. wine as we know it

To visualize these numbers, this cross-country shipment generates the wine's own weight in CO_2 even when using the lightest bottles! That is eight times the amount of carbon dioxide produced during alcoholic fermentation. This calculation does not even include the shipping of empty bottles from China or Mexico to your winery, or any recycling efforts. Domestic or international bulk wine shipments do not help either, since you still need to ship the bottles separately. Realistically, the only way to minimize wine's heavy carbon footprint is to drink more locally grown wines and recycle/reuse containers locally as well. We shall see that when Modesto freezes over!

One blog mentioned the idea of switching to PET bottles to lower wine's overall carbon footprint: "We get a total CO_2 emission for a plastic wine bottle of 3.8 oz per bottle compared to 10.4 oz for a glass bottle." (Retrieved from http://wineenabler.com/comparing-the-carbon-footprint-of-plastic-and-glass-wine-bottles.)

Late in 2011, the British GreenBottle company introduced a two-ounce (55 gram) wine bottle made from – yes, you guessed it – paper. The "bottle" consists of a paper shell that is "compostable and biodegradable" (much like wine itself!) that has an inner wine-proof liner made from recycled plastic (retrieved from http://www.greenbottle.com).

Thereafter, this is where we stand: You take away natural cork, the arcane labels, the serious wine writers, and at last, the glass bottle, and the transformation of wine is finally complete: The world's most value-added, image-driven, awesome agricultural commodity has become a sustainable, fortified soda pop. Drought, food shortages, extinction of species — and a handful of LEED Platinum wineries to save us all! I say let's all plant Nebbiolo and have our kids figure it out. *Drink now and drink local!* ■

P.S. And yes, for the record, I do drink all that leftover wine from the Indy. Cheers!

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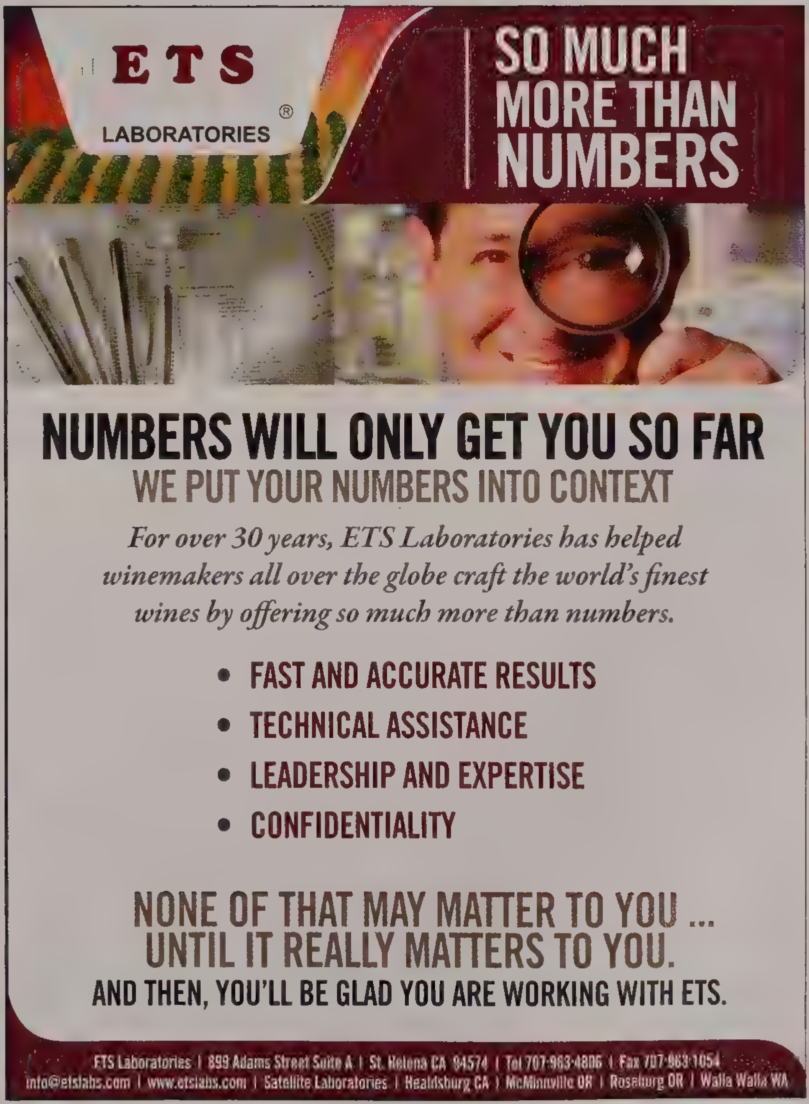
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New licensing for DTC wine sales in California

BY Bahaneh Hobel, Michael Mann,
Dickenson, Peatman & Fogarty's Alcohol Beverage Group

Effective January 1, 2012, a new alcohol beverage license allowing direct-to-consumer (DTC) sales of wine via internet, phone, or mail became available in California. This new license allows online retailers to make DTC sales of wine without requiring such retailers to also make sales at the wholesale level, as had previously been required.

The feasibility of DTC retail internet sales has been an issue in the wine industry for many years. Originally, the discussion seemed to center around the requirement for a retail storefront for DTC sales.

Retail wine sales to consumers were traditionally conducted from premises holding (among other license types) a Type 20 Off-Sale Beer and Wine License. A Type 20 license holder was required to maintain premises open to the public that made retail sales to walk-in consumers — a "retail storefront." Type 20 license holders were also permitted to make sales through other channels, including phone or internet sales.

However, as interest in DTC sales over the internet increased, a licensing problem emerged for many potential online businesses looking to get into the wine industry. Because of the retail storefront requirement of the Type 20 license, DTC sales via the internet by companies without such a storefront were not permissible. For many, a retail storefront was not a possibility, whether from a financial or operational standpoint, or simply because it was not part of their business plan.

In 1995, the Department of Alcoholic Beverage Control (ABC) issued a moratorium on Type 20 licenses in areas of over-concentration, even further limiting the availability of such licenses within California. This issue really came into focus with the growth of custom crush wine in the wine industry.

In the custom crush scenario, a winery produces wine for another person or entity under a brand name owned by that person or entity. Such custom crush clients/brand owners needed the ability to sell the wines that had been produced for them directly to consumers.

The "17/20 license," a combination of a Type 17 Beer and Wine Wholesaler license and a Type 20 Off-Sale Retail Beer and Wine license, addressed this need. The 17/20 license was made possible in 1988 by enactment of a specific exception to the tied-house laws (which prohibit ownership in both a supplier-side and retail license). With this exception, the holder of a 17/20 license was permitted to make direct sales of wine (but not beer) to the consumer, but was also required, under its Type 17 license, to make sales at the wholesale level every 45 days.

Originally, 17/20 license holders were also permitted to operate from a storefront if they chose to. However, following the moratorium on Type 20 licenses, 17/20 licenses were essentially only issued where the license holder agreed to restrict its DTC wine sales to those made by phone, internet, or mail order.

As creation of the 17/20 license opened the door to selling wine direct to consumers without having to invest in a brick and mortar retail storefront, it also required licensees to operate in good faith as bona fide wholesalers, making sales to licensed retailers every 45 days.

In the last 15 years, this wholesaler requirement proved especially problematic for those 17/20 licensees whose businesses were focused on the burgeoning DTC internet wine sales industry. If they failed to meet the wholesaler requirement, they risked potential enforcement action.

Holders of the new Type 85 license will now be able to make direct sales to consumers via internet, phone, or mail, subject to compliance with other state and federal laws, without the additional burden of making sales at the wholesale level to licensed retailers.

Current Type 17/20 licensees who have a consumer-focused business plan could therefore transition to the new license and validly conduct consumer-only sales without having to allocate valuable time, money, and resources to complying with the wholesale requirements of the 17/20 license.

In addition to the sales privileges of the new license, Type 85 license holders will also be permitted to donate wine to certain exempt nonprofit organizations. Like 17/20 licensees, Type 85 licensees will be given the privilege of participating in certain limited wine tastings events involving nonprofit organizations holding a temporary wine license.

However, their involvement is such tastings will be limited to and can only include wines that were produced on a custom crush basis for the Type 85 licensee under a brand name owned exclusively by that licensee, and that were donated to that nonprofit by the Type 85 licensee. Participation in such tastings is often a key component of a new wine venture's marketing strategy and is a great way to connect with the consumer.

Although the Type 85 is a new license, Type 85 licensees still remain subject to many of the same conditions and restrictions that apply to holders of the Type 17/20 license combination.

For example, DTC sales are still restricted to those solicited and accepted via direct mail, telephone, or the internet and are limited to 52 gallons per sale. This means that no "in-person" sales are permitted. Sales also cannot be conducted from a retail premises or storefront that is open to the public.

Type 85 license holders are also subject to all federal and state rules and regulations governing the sales of alcohol in California. For example, they must follow the rules prohibiting consignment sales, and are required to first purchase and take possession and title of any wine they intend to sell. Agreements that allow the licensee to "only pay for what sells" or that permit the return of any unsold wines to the producer or wholesaler are not permitted and could be pursued by the ABC.

Type 85 license holders must also comply with the myriad rules regarding the direct shipping of wine, which vary from state to state. Finally, unlike the Type 17/20 license combination, there are no exceptions to the tied-house laws that were created for the Type 85 retail licensee. As such, the holder of a Type 85 license could not have any interest in a manufacturer or wholesale license in California.

The Type 85 license is a great step forward in the industry and will nicely enhance the DTC wine market that already exists in California. Creation of the new license also demonstrates that the California ABC and the state legislature are attempting to keep abreast of and respond to issues that are important to licensees within the state, and we hope to see this pattern continue in the future. ■

Bahaneh Hobel is an attorney in Dickenson, Peatman & Fogarty's Alcohol Beverage Group. Michael Mann, a career veteran of California Department of Alcoholic Beverage Control, is a consultant in Dickenson, Peatman & Fogarty's Alcohol Beverage Group, Napa, CA.

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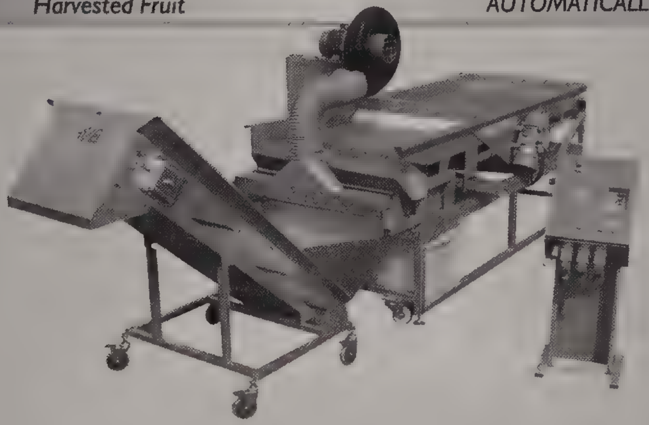

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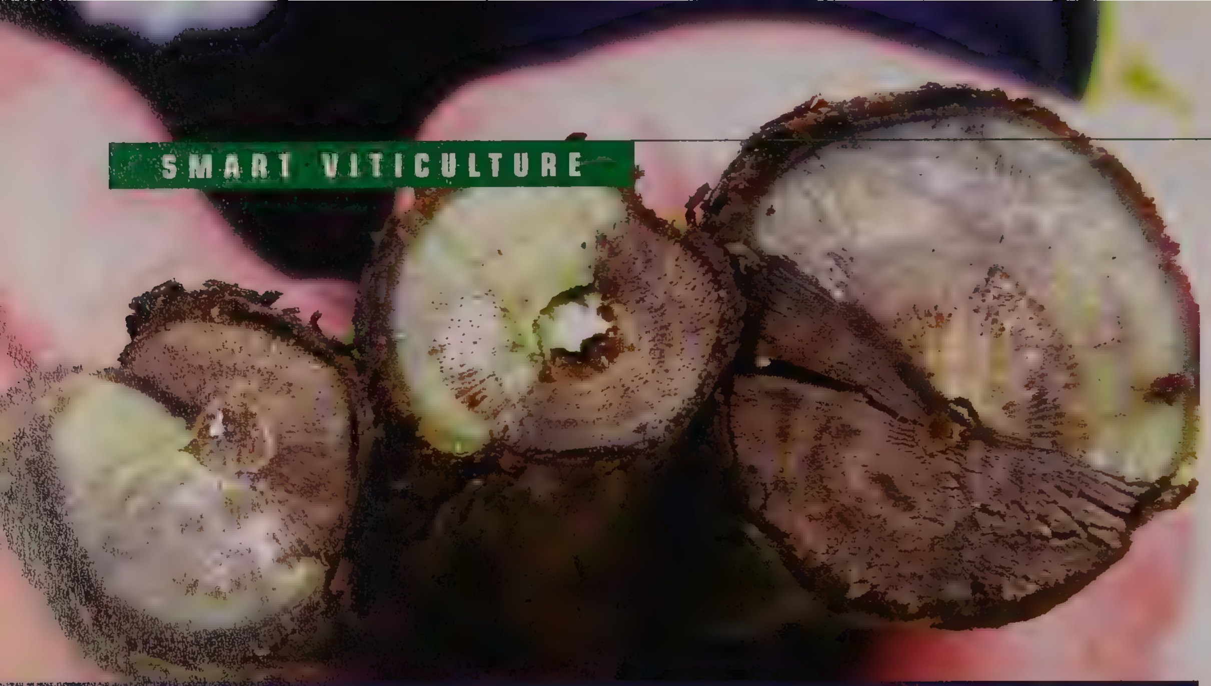


◀ **The early stages of development of a canker and trunk staining, young trunk of Pinot Noir infected with *Botryosphaeria*. (United Kingdom)**

GRAPEVINE TRUNK DISEASES: A new global vineyard threat?

Dr. Richard Smart

Grapevine trunk diseases, a complex of fungal diseases, seem recently to be taking on a whole new dimension. Let me explain.

In the 1970s, I had a small vineyard in the Barossa Valley (Australia), and some vines were more than 30 years old. This is a winter rainfall area, like California. I was not surprised that many vines showed Eutypa trunk disease symptoms. However, as was common in the area, infection was generally limited.

The old vines were often unwanted varieties, so the problem was not major. That is not necessarily the case today, as younger vineyards of desirable varieties are now showing Eutypa symptoms. The spread of the disease, through infected pruning wounds, is difficult to avoid.

During my travels, I also became exposed to Esca, called Black Measles in California. It can be a very difficult disease to control in Europe, and can be very damaging. I have seen Tuscan vineyards with very high incidence, and substantial crop losses.

Both Eutypa and Esca have been known for many decades, but a new group of fungi of the genus *Botryosphaeria* is the group lately receiving research attention. I have seen this fungus disease recently in many countries, and generally the problem had been unobserved and undiagnosed.

Problem in UK vineyards

I moved to Cornwall (United Kingdom) in May 2011, and visited vineyards to advise on sustainability issues. This program and private visits gave me the opportunity to visit over 35 vineyards in three tours — in summer, autumn, and winter. Many vineyards had unhealthy vines and some dead vines, often in patches. Looking for causes for the problem I found trunk staining; the more staining the more unhealthy, or even dead, was the vine.

Contact with colleagues around the world and web searches led me to *Botryosphaeria* trunk disease, which was confirmed as *Botryosphaeria parva* by government scientists. This disease was unknown in UK vineyards before, and there has been some reluctance by growers to accept this as a common cause of ill thrift, yet I found symptoms in all but one UK vineyard.

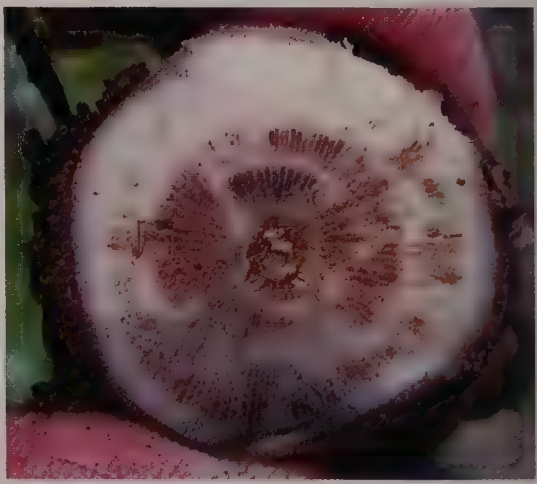
Now, after several workshops, and a seminar involving an Italian researcher specialist, growers are coming to grips with the need to protect pruning wounds in the wet, mild UK winter. There is no cure for infected vines, as is common for trunk diseases, and they must be removed from the vineyard as they are a source of spores and thus spread of infection.

Unfortunately, many newly planted vineyards are also affected by trunk disease in the UK. Grafted vines are imported from Europe and high proportions of vines fail in the first and second year. Staining of the trunk and scion wood can be seen in some delivered plants, suggesting a possible double infection by *Cylindrocarpon* at the base, and *Botryosphaeria* in the scion. Many of these plants die, or fail to thrive. *Cylindrocarpon* is another fungal trunk disease often found in plants delivered from nurseries, and it is sometimes called "Black Foot" disease.

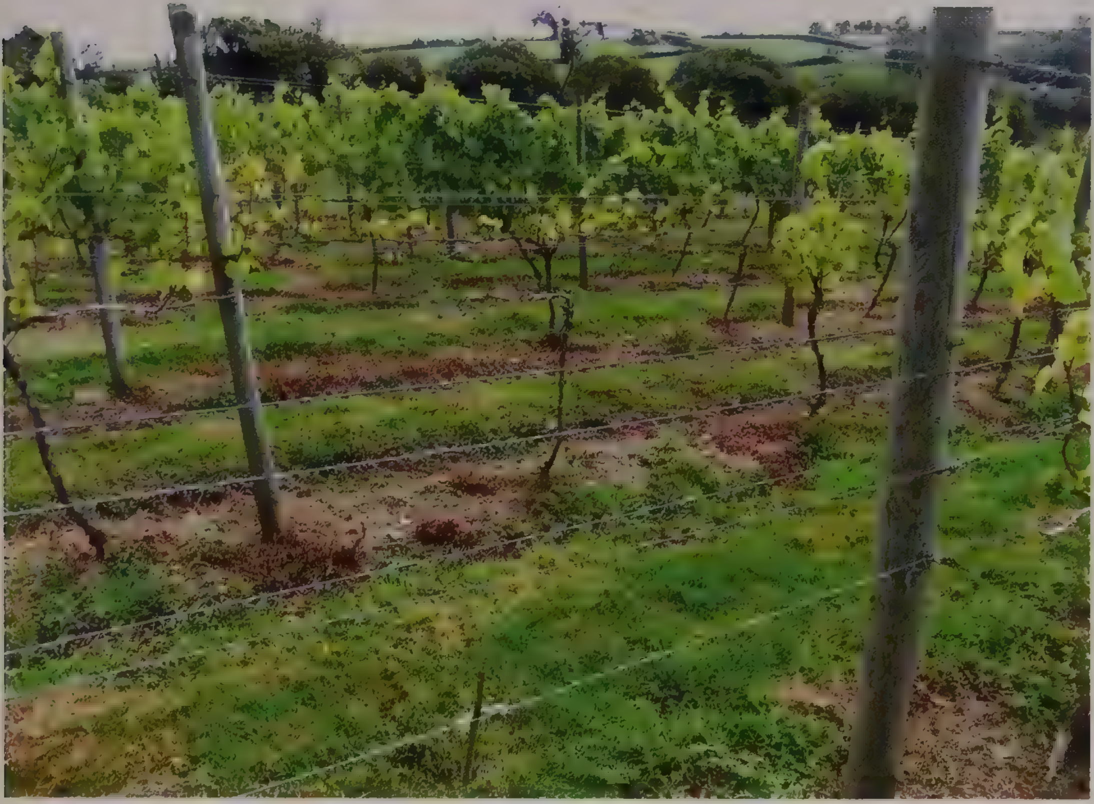
Elsewhere in the world

In 2011, I visited several other countries where I saw trunk disease, to the extent I wondered if it was following me around! My first visit was in Mexico, noting problems on young and old vines, and I have subsequently seen excellent papers in the *American Journal of Enology & Viticulture* describing what I saw. A local scientist is studying the problem, and she is a member of the International Council of Grapevine Trunk Diseases, which is having its eighth meeting in Valencia, Spain in 2012.

There was less awareness in Turkey, where I again saw problems with old and young vineyards, but fortunately very restricted. In Thailand, the situation was very different. Here there



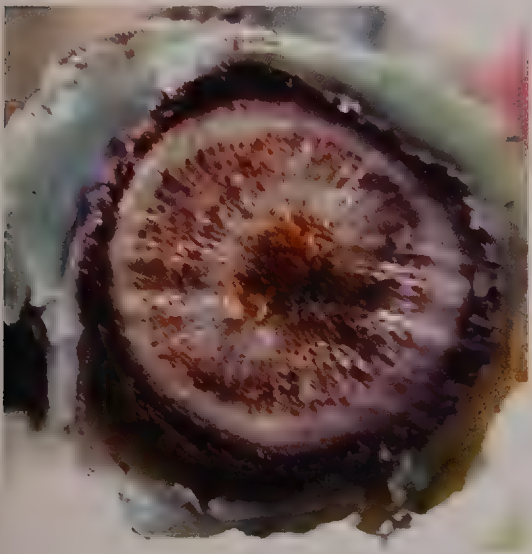
Typical *Botryosphaeria* symptoms Pinot Noir trunk (United Kingdom).



A vineyard in United Kingdom showing effects of *Botryosphaeria* spread. Note missing vines, low vigor and yellow vines, and vines with failed bud break.

is a limited area of wine grape viticulture, but some very enthusiastic winemakers, and some good wines are being produced from vines yielding two crops per year. This means that they are pruned twice each year, and again the weather can be wet and humid.

Old Thailand vineyards were in a dreadful state, with many dead vines, and trunk staining everywhere. A *Botryosphaeria* disease is recorded there in mango, so I suppose it is also quite common in the vineyards; symptoms would indicate it as an initial isolation. More work needs to be done there to stop what is a very obvious spread of disease, so that the present young vineyards may become old and remain productive.



Staining in top of rootstock of failed one-year-old vine apparently from a pruning cut made at a United Kingdom nursery, present under the wax which was present when the vine was delivered.

My last two visits were to northern Europe, to zones at the very edge of cool climate viticulture, Belgium and Norway. In both places I have tasted surprisingly very pleasant wines, including Pinot Noir in Belgium. Both countries were planting new vineyards, and they showed an unacceptable proportion of dead and sick vines. The vines I looked at had trunk and rootstock staining, again typical of trunk disease. Here, as in the UK, many young vineyards planted by enthusiasts are destined to fail because of trunk disease. Again the grafted grapevines were imported from Europe, suggesting problems with nursery procedures and maybe grafting material.

During a three-year project completed in June/2010, Dion Mundy (Scientist at Plant & Food Research, Marlborough Wine Research Centre), reports that regional surveys of vineyards in six of New Zealand's major wine-growing regions provided incidence data for grapevine trunk pathogens including species of *Botryosphaeria*, *Phaeomoniella*, Eutypa, *Phomopsis* and *Phaeoacremonium*.

CALIFORNIA INPUT

"After the appearance of the new biotypes of Phylloxera, followed by new plantings state-wide, there was a big demand to replace lost vines and meet market demand," recalls Paul Verdegaal, University of California Farm Advisor. "This led to much new planting material that was substandard from a short supply of propagation materials. Also, improper planting in new and replant vineyards caused stress; making new vines more susceptible to dieback problems.

"Since *Botryosphaeria* has the same canker development, but shows no foliar symptoms in the spring, it's possible the organism has been around quite awhile before it was identified as a separate pathogen in vine dieback. Northern regions have tended to test more for *Eutypa*, while southern regions have more *Botryosphaeria*. The Lodi region seems to split with half of each on a vineyard-by-vineyard basis.

"Along with *Eutypa* and *Botryosphaeria* attention to Esca, which includes the complex of pathogens such as *Phaeoacremonium Phaeomoniella spp*, and others, requires further study, as part of the overall canker disease problem.

"In addition, during recent years more susceptible varieties have become dominant in commercial production. Vines that are pushed to produce early, followed by deficit irrigation, and spur pruning; have all possibly led to increased incidence of grapevine trunk diseases."

Returning to California

What is the situation now in California? Are there any contaminated vines being planted, as elsewhere in the world? Studies in many countries have shown that rootstock and scion source blocks can be infected by trunk diseases such as *Botryosphaeria* and *Cylindrocarpon*. Yes, you guessed it, through untreated pruning wounds of vines in source blocks. Some of these source blocks have dead or sick vines, which have hitherto been ignored. This is recorded in Australia and Europe. What is the case in California?

My mind goes back to the late 1980s and early 1990s, after the AXR and phylloxera biotype debacle, when so many California vineyards were removed. I do remember the piles of dead vines, waiting to be burned after removal from vineyards, what a graphic sight!

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Then examples of poor young vine growth followed, even death, for vines grafted on "alternate" rootstocks. Thus we had Lucy Morton crying "all is not well," to protests from nurserymen and others. Eventually good sense and science won out, the term "Black Goo" was dropped (but did not die), and the first meeting of the newly formed International Council of Grapevine Trunk diseases was held in California in 1998.

Now California takes the lead again, with awareness of Eutypa and *Botryosphaeria* in vineyards. Dr. Doug Gubler and colleagues from UC Davis published a ***PWV*** article in Jan/Feb 2005 on these diseases. Both are important in California, as both lead to loss of production and high treatment costs.

Researchers around the world note that trunk diseases are becoming **more** rather than less common. Why is this, especially for young vines? I wonder if "source blocks" planted 10 to 30 years ago to combat virus problems might not be a problem themselves, having accumulated enough pruning wounds and maybe infecting fungi, to produce contaminated cuttings?

Conclusions

Reports of trunk disease of vineyards continue to come in from most every vine-producing country, many more than my personal sample listed here. Trunk diseases are also reported in New York State, and elsewhere in the eastern U.S. Are we seeing a new "epidemic," or at least widespread disease? Only time will tell. ■

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VINEYARD SHOWCASE

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Photo: Mechanical leaf removal by Walsh Vineyards Management on a Pellenc over-the-row chassis in a Carneros [California] Chardonnay vineyard.

WESTERN SQUARE INDUSTRIES

Western Square customers can follow the company and stay up to date with the wine industry on Facebook and LinkedIn.

Western Square is excited to introduce a new sales team: Bobby Fox in Paso Robles; Margaret Abajian in Napa (with extensive sales experience in the Napa schools and community); Adam Shindelbower brings his brewery experience to Central California and Oregon; and John Bridell rounds out the vineyard and agricultural operations.

Abajian

Bridell

Fox

Shindelbower

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OXBO INTERNATIONAL CORP.

Oxbo continues to build on the legacy of the Korvan brand, designing and building innovative grape harvesters that deliver maximum in-field productivity.

American-made Oxbo harvesters feature unique high-capacity buckets and an industry-leading three-fan cleaning system. These features, along with effective bow-rod or trunk-shaking style picking heads, enable Oxbo harvesters to deliver high-quality fruit without sacrificing harvesting speed. Each model is available with many options, allowing you to customize the harvester for your field conditions. Oxbo understands the need for uptime, and has designed every machine for low yearly maintenance cost, easily available parts, and local service through its dealer network.

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Brent Borboa, Market Manager
tel: 559/281-1883
e-mail: bborboa@oxbocorp.com
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Bird Gard is a world leader in electronic bird control, protecting millions of vineyard acres worldwide.

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CALIFORNIA SEED & PLANT LAB

California Seed and Plant Lab (Cal-SPL) located near Sacramento, CA, offers plant disease testing and genetic identification of grapevine varieties. The firm, established in 1995, employs a highly qualified technical staff, including Ph.D. and MS scientists.

Disease diagnosis: Cal-SPL offers a 17-virus PCR test to identify all viruses known to be present in California vineyards. Growers can identify healthy vines and start new plantings from healthy vines. Other economically important diseases including young vine decline (*Phaeoacremonium spp*) are also identified.

Virus elimination: Cal-SPL offers meristem services to eradicate virus infections from your favorite cultivar.

Soil health: Cal-SPL offers analysis of soil and enumerates beneficial microorganisms to such important pathogens as *Agrobacterium* (crown gall) and *Cylindrocarpon* (root rot). The analysis helps growers to choose a suitable organic amendment or compost tea to incorporate into soils for maximum yield.

Variety DNA identification: Genetic testing includes fingerprinting of varieties with an 8-marker DNA test. The fingerprint is compared with the varietal database (Cal-SPL has all varieties grown in California in the database). Fingerprinting service can also provide genetic profiling for patent applications.

For more information, contact:
California Seed & Plant Lab
Parm Randhawa, Ph.D.
7877 Pleasant Grove Rd, Elverta, CA 95626
tel: 916/ 655-1581; fax: 916/655-1582
e-mail: randhawa@calspl.com
website: www.calspl.com

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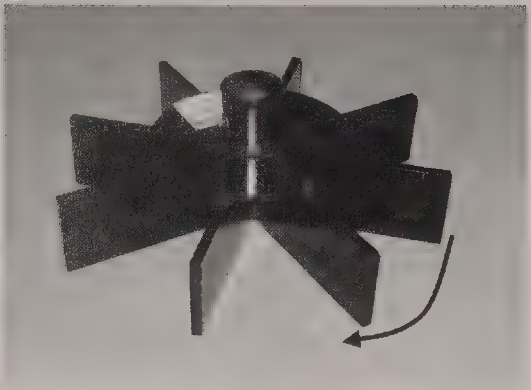
WEED BADGER® PADDLE WHEEL

The newest introduction to Weed Badger's line of precision interchangeable tools is the Paddle Wheel. It is primarily used to hill down soil in the Spring with no digging or hand labor. The Paddle Wheel rotates bi-directionally using Weed Badger's exclusive reversible rotation.



Return fugitive soil from row middles or reshape vine rows after in-row cultivation. A final cleanup pass will finish the task, using Weed Badger Sweeper/ Tiller Teeth or the Badger Broom. The Paddle Wheel attachment can be used on any Weed Badger tiller machine.

The Paddle Wheel was developed at Michigan State University by Dr. Tom Zabadal, Gary Van Ee, and Richard Ledebuhr.

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5673 95th Avenue SE
Marion, North Dakota 58466
Tel: 800/437-3392; fax: 701/778-7501
e-mail: inquiry@weedbadger.com
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VINTAGE NURSERIES

Vintage Nurseries is one of North America's largest producers of dormant field-grown benchgrafts. Vintage Nurseries' advanced facility provides excellent quality control. Customers receive good value, with high-quality grapevines, olive and pomegranate trees at competitive price-points. Vintage Nurseries includes hot-water-dipping on its vines, designed to eliminate vine mealybugs and other pests and pathogens, at no extra cost.

Vintage Nurseries also produces greenhouse-grown benchgrafts, rootstock rootings, own-rooted vines, and cuttings. Located in California's southern San Joaquin Valley, Vintage Nurseries propagates all plants in one of North America's best climates for a grapevine nursery.

Vintage Nurseries currently has a wide selection of popular varieties including Syrah, Pinot Noir, Cabernet, Merlot, Sauvignon Blanc, Chardonnay, and many more. Vintage Nurseries also offers table grape releases: Scarlet Royal, Autumn King, and Sweet Scarlet, and other table and raisin grape varieties.

All customers and industry professionals are welcome to visit the facility and growing grounds.

For more information, contact:
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Nicholas Podsakoff, North Coast CA, Texas, Canada:
tel: 209/456-0697
Dave Haggmark, North Coast CA, Eastern U.S.:
tel: 805/391-0905
Mike Enns, South Valley wine grapes, table grapes:
tel: 661/747-1582
Dustin Hooper, Sales Manager, Oregon, Washington:
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MARRONE BIO INNOVATIONS

For grape growers, Marrone Bio Innovations (MBI) currently markets Regalia® biofungicide and Grandevo™ bioinsecticide (coming soon in California).

Regalia controls powdery mildew, botrytis bunch rot, and summer bunch rot (sour rot) in grapes. Regalia induces the plant's defenses, provides bacterial and fungal disease control, delays the development of resistance, and helps minimize chemical residues in harvested grapes. In short, Regalia is proven to make a vineyard protection program better. Add Regalia to your IPM program for better plant health, better yield, and a better bottom line.

Regalia®

MBI has also received EPA approval for Grandevo™, a broad-spectrum, highly effective natural insecticide for use on agricultural and ornamental crops. Look for this groundbreaking new product later in 2012.

For more information, contact:

Marrone Bio Innovations
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e-mail: info@marronebio.com
website: www.marronebio.com
Jesse Rosales, Coastal CA
tel: 530/304-2030
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Vineyard Industry Products (VIP) are specialists in vineyard trellising and super high-density olive orchards.

Since 1979, VIP has supplied growers with high-quality trellis materials and supplies. With three fully stocked yards and nationwide distribution, VIP delivers vineyard materials when they are needed. In addition to steel products like T-posts, highway posts, rebar, wire, and cross arms, VIP carries accessory items like pruning shears, tie tape, and bird netting. Please visit the VIP website, vinbiz.com, for a complete listing of products.

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toll free: 800/544-2210
website: vineyardindustryproducts.com
or vinbiz.com

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ADVANCED VITICULTURE, INC.

Advanced Viticulture, Inc. is a winegrowing consulting and management company that operates from a standpoint of sustainability. With principal viticulturist Mark Greenspan, and a philosophy of minimal inputs to the vineyard, Advanced Viticulture achieves environmental protection, and reduction of fertilizer and irrigation inputs, allowing the vineyard's characteristics to shine through.

Advanced Viticulture offers turn-key monitoring services for irrigation management, with soil moisture data logging systems, frequent measurement of plant water status, and weekly updates including current moisture status and water management advice. Service packages may be limited to water management, or may include other aspects of sustainable viticultural practice. Moisture monitoring equipment is available for sale, or equipment may be trialed using affordable leasing programs. Advanced Viticulture now partners with Ranch Systems to offer a wireless cellular soil moisture measurement station.

Advanced Viticulture employs the SIS™ Soil Information System to create detailed soil maps, interpreting information to develop recommendations ranging from detailed vineyard design, to irrigation system modifications, to remediation and improvement of existing vineyards.

AV

Vineyard management services are offered for small- to medium-size vineyards, with a full-time experienced vineyard manager on staff, and with full-service and custom vineyard operations. Few other vineyard management companies combine refined technical expertise with "get it done" practical know-how.

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930 Shiloh Rd, Bldg 38B, Windsor, CA 95492
tel: 707/838-3805
e-mail: info@advancedvit.com
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KINGSBURG CULTIVATOR, INC.

Kingsburg Cultivator Inc. (KCI) started in the vineyard manufacturing business 45 years ago. Story has it they took a lawn mower head, and cut away the shroud to expose the blade with an old Briggs & Stratton engine mounted to a 8N tractor, thus introducing the first front-mount cane-cutter. From then on, KCI has been a leader in innovation and the newest technology.

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tel: 800/300-2220
fax: 559/897-0201
e-mail: sales@kci-mfg.com
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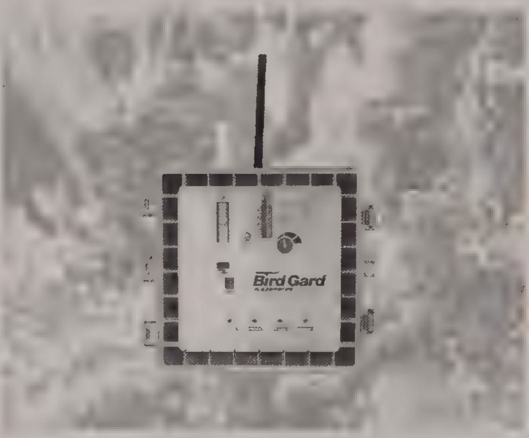

Each controller/transmitter includes one four-speaker receiver protecting up to six acres from bird damage ($799). Additional four-speaker receivers are $400. One system can be customized to protect 12, 18, 24, 30, 36, 42, or 48 acres.

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For more information, contact:
Duarte Nursery, Inc.
1555 Baldwin Rd., Hughson, CA 95326
tel: 209/531-0351; fax: 209/531-0352
e-mail: sales@duartenursery.com
website: www.duartenursery.com

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DYNAMAX, INC.

Dynamax, Inc. manufactures the SapIP systems and the Dynagage and EXO sensors for measuring plant water use in "real time" with no calibration. These systems and sensors can determine how much water a grapevine is using in grams or milliliters per hour. The sensors do not penetrate the plant or harm the vine in any way, and are easily strapped onto a vine with Velcro straps.

Fruition Sciences, located in California, are experts at vineyard management and use the Dynamax SapIP wireless sap flow system and the EXO sap flow sensors to monitor vineyard water use and irrigate and manage accordingly.

Managing water availability to the vine influences the characteristics and quality of the grapes. The objective of most irrigation strategies is to achieve an optimal level of vine stress to improve wine grape quality. Fruition Sciences uses the sap flow sensors to measure how much water the vine is transpiring through its leaves, and then determines an irrigation rate needed to achieve the desired plant stress level and fruit quality.

Fruition offers complete vineyard management services.

For more information, contact:

Dynamax, Inc.
10808 Fallstone Rd. #350, Houston, TX 77099
tel: 281/564-5100
websites: www.dynamax.com
and www.fruitionsciences.com

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KINSEY AGRICULTURAL SERVICES, INC.

Kinsey offers nutrient management and development for rebuilding vineyard soil quality – a detailed program of specific procedures especially designed to correctly define, measure, and manage vineyard soil fertility.

Specific tests are utilized to measure, map for sampling, and analyze vineyard soils. The program can accurately determine nutrient requirements for every significant variation in the soils of each vineyard utilizing detailed soil tests combined with optional GPS technology. By identifying the subtleties of each soil and resulting consequences for grapes from nutrient deficiencies or excesses, potential advantages and/or problems can be detected and the appropriate solutions proposed.

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For more information contact:

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tel: 573/683-3880; fax: 573/683-6227
e-mail: neal@kinseyag.com
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Plantra, a North American vine and tree establishment leader, is dedicated to designing products that unleash the full growth potential of planting stock.

Jump Start® Grow Tubes: A faster way to get newly panted vines and orchard trees established and into production is to shelter them with a greenhouse micro-climate during their first season in the field. Jump Start "mini-greenhouses" get new plantings off and running with the sun. Twin-walled for light diffusion, and translucent to growth-optimizing sunlight the plants need, Jump Start® Grow Tubes are packed with advanced greenhouse technology, to stimulate phytochrome and grow the whole plant – from roots to shoots – for earlier, larger, and sustained harvests.

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Spray Innovations offers a line of low volume mist blowers to match practically any spraying need.

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Swihart Sales Company
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WHY does a DISTRIBUTOR take on a WINERY?

BY Dr. Steve Goodman, University of Adelaide Business School

Choosing wine carries a perceived risk,[12] for consumers and business customers alike. A distributor can only represent so many wineries. Customers are looking to be able to “trust” in the purchase they make; the work of many researchers has been to identify “what” consumers trust about wine.

Large brands represent a level of risk minimization; they require less knowledge to be able to make a buying decision.[2,12,16] The wider a brand is known, the more a consumer is exposed to a brand, the more likely they are to have a positive attitude about the brand.[22] We expect then, that business customers will also value “'brands” as an influence in their decision.

Research has also shown that origin/region can be a substitute for brand in terms of a quality indicator. [2,15,25,28] In some cases we have seen the region becoming the brand[20] especially with higher spending, discerning wine consumers.[15] Different regions command different price premiums, some are more of a brand than others.[19]

There is trust with both regions and brands3 often because the consumer is forced to rely on a multitude of extrinsic factors.[13] Region has been shown to have the highest utility among greater knowledge consumers.[21,14,27] We might expect to see a difference in the influence region has on distributors with varying sales volumes; smaller volume distributors (at likely higher price point wines, higher quality/lower volume) might be more influenced by region than brand, and vice versa.

This is one in a series of papers presenting results from research funded by the Grape Wine Research and Development Corporation (Australia) that examines “decision influencers” among trade customers and distributors on which wine to buy in, promote, and represent. For further details and information please contact steve.goodman@adelaide.edu.au

Business to business (B2b) customers are reliant on fewer customers than business to consumer (B2c) businesses, so the portfolio presented to the market is very important,[4] a factor that may translate into which winery to represent; range can be everything.[6]

R. Tipples reported on the importance of a retailer valuing receipt of one invoice for a number of wineries; the cost and ease of dealing with one account for a number of wines is important in B2b.[26] As G. Zsidisin and L. Ellram postulate,[29] the B2b company needs to acquire what best helps them achieve their objective; sourcing the supplies that best meet their and their customer's needs is a central tenet to relationship marketing and successful B2B operations.[4] As consumers are more likely to repurchase from the same price point, the price point targeted (or possible to target) of the winery is likely to be an influence on a distributor's decision.[17]

Research showed that previous taste was a significant influencer of consumer choice,[8,9,10] so a wine supply chain of industry professionals is likely to be influenced by taste. Expectations, likely to be generated by anticipation of future business, the brand, region or even winemaker/owner character[23] can override the taster's sensory perception.[28]

While knowledge of wine is important, in the business channel knowing how to sell it is critical and more likely to influence sales.[6] Sommeliers, those responsible for wine sales in the on-premise setting, are influenced by value (for money), variety, taste, and reputation.[6] This raises the question: do those distributors focusing at the on-premise market count factors such as the above as more of an influence than those with an off-premise focus?

Some retailer's value merchandising support, while others simply seek payment to cover the retailer's cost of conducting in-store tastings.[26] In terms of sustainability, having a supply chain working together with the understanding of what its customers (and its customer's customers) want, is crucial for the creation of value for all those involved in the supply (value) chain from the winery to the consumer.

Method

Qualitative interviews were held, in-person and by telephone, with members of the wine supply chain to discuss the factors important to them when making decisions as to which wine to buy in or represent. From these interviews, a decision set was compiled for use in a quantitative study. The data was collected online using a Best-Worst design of 13 decision influencers.[8]

An email was sent to 121 wine distributors in Australia inviting them to complete the survey. This represents the population of licensed distributors that distribute wines within Australia (excluding those companies that only represent brands they own). Useable responses were received from 22 distributors (an 18% response rate). As this is a population sampling, 18% is a satisfactory sample size to investigate.

Furthermore, the Best-Worst choice method enables data to be examined from smaller numbers of responses; in fact, estimations are available and accurate at the individual respondent level.[5,7]

Responses were received from the various states in Australia broadly in line with market share of wine

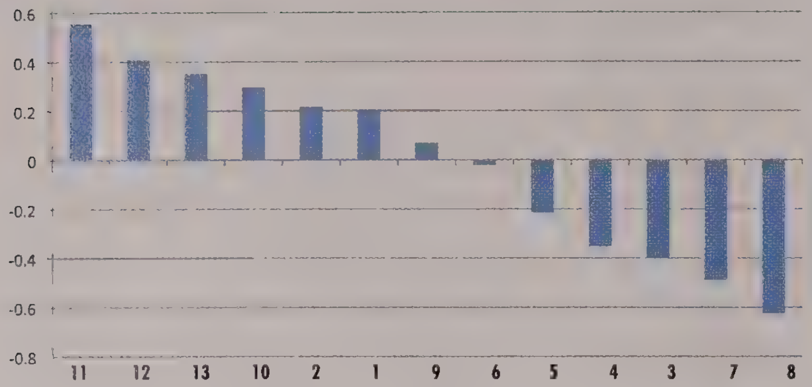

Figure 1 —What influences your decision when looking at taking on a new winery? Australian Distributors (n=22)

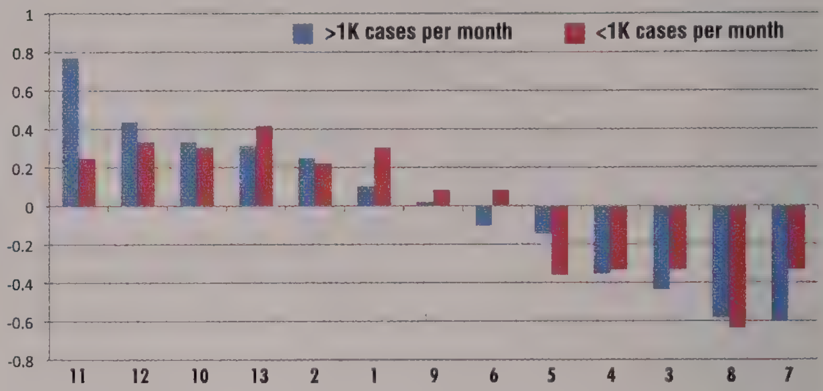

Figure 2 —Differences between Low (n=12) and High (n=12) volume wine distributors

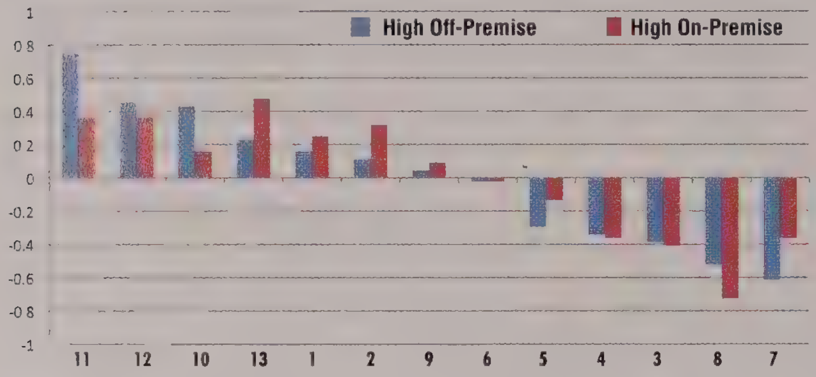

Figure 3 –Differences between on- (n=11) and off-premise (n=11) focused distributors

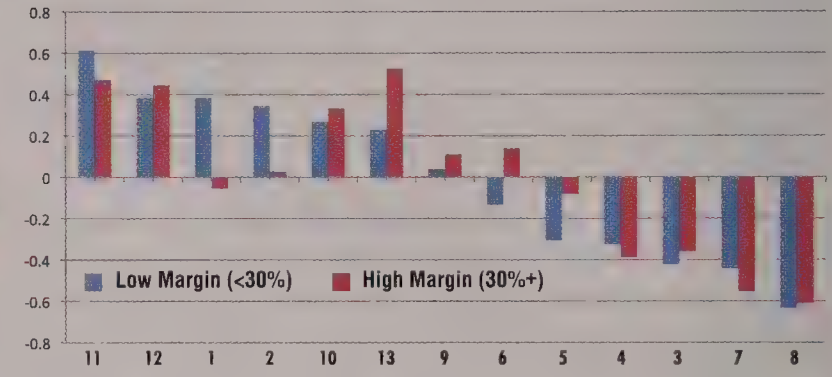

Figure 4 –Differences between High (n=9) and Low (n=13) margin wine distributors

Figures Key

1. Retail price point
2. Margin
3. Tasting stock allowance
4. A&P Contribution
5. Write ups and features
6. Medals and Awards
7. Vintage/aged wine
8. Merchandise support
9. Grape variety
10. Range of wine offered
11. Brand
12. Origin/Region
13. Like the taste

sales per state. New South Wales and Victoria represented 60% of responses, South Australia and Western Australia 31%, suggesting a broadly representative national sample of decision-making.

Results

Figure 1 shows the results across all respondents in decreasing influence on the decision. Those below the line are not negative -- simply the lower the standardized score, the less influence it has on the decision to take on a new winery.

At a full sample level, brand was the most important influencer of choice, 25% more so than Origin/Region.[2]

Taste was important (fourth) as was the range of wines offered by the winery (fifth). Margin and retail price point ranked similar influence while, interestingly, the actual grape variety scored relatively low; this may be offset though as the distributor is more looking at the range of grape varieties produced as wine by the principal.

Typically, wine is seen as either a "commodity" wine, with sales driven by volume or as "fine wine" where volumes are typically smaller. How does the sales volume of a distributor affect their choice of winery to represent? Figure 2 gives a comparison between High and Low

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volume distributors (HVD and LVD).

HVD are substantially more influenced by brand than LVD; while this is to be expected it is now present in empirical results. LVD have their opinion of the taste as the biggest influence on the decision and are substantially more influenced by that, and the retail price point than HVD are. This infers a very different approach and business logic, between distributors of different sales levels.

A winery approaching a distributor that takes them into a portfolio based on feedback of "taste" and "retail price point" may need to see if it is with the mindset and position of expected smaller volume sales. It could be that feedback like this from a distributor to a winery principal is tied to the sales levels of the distributor concerned.

While on and off-premise are arguably both the "retail" wine channel, they represent different situations and are seen to show different behavioural responses.[5,8,10] The question arises: do distributors with a business orientation and sales to on or off-premise differ in their decision influencers concerning the wine they carry?

Figure 3 shows that there are several notable differences. Brand and the range of wine offered are much more of an influence for those with an off-premise focus while those with a focus toward on-premise are much more influenced by taste and margin. Those on-premise respondents interviewed in the qualitative phase reported the importance of margin often mentioning the importance of it in the overall profit of the restaurant.

While quantitative data needs to be gathered from trade customers, there appears to be an alignment between the later stage customers of the supply chain; the question is whether the wineries seeking to tap into this market offer products that suit the downstream chain members.

The importance of attitude to brand and taste is evident when segmenting the responses using the average trade margin received by distributors. Lower Margin Distributors (LMD) are much more influenced by brand and

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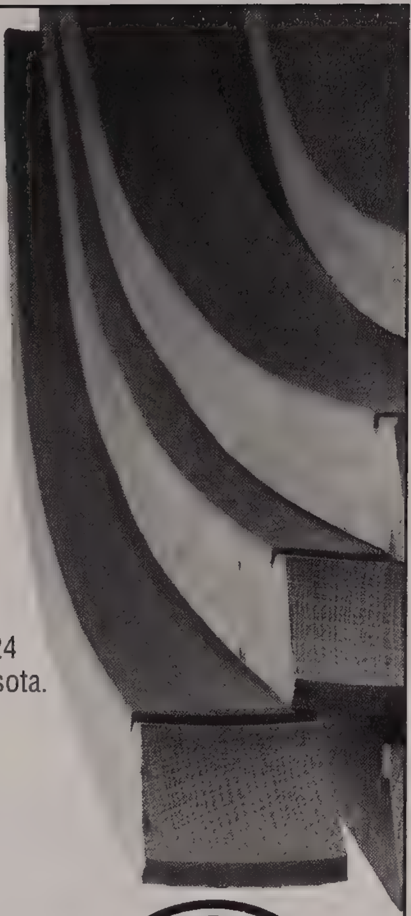

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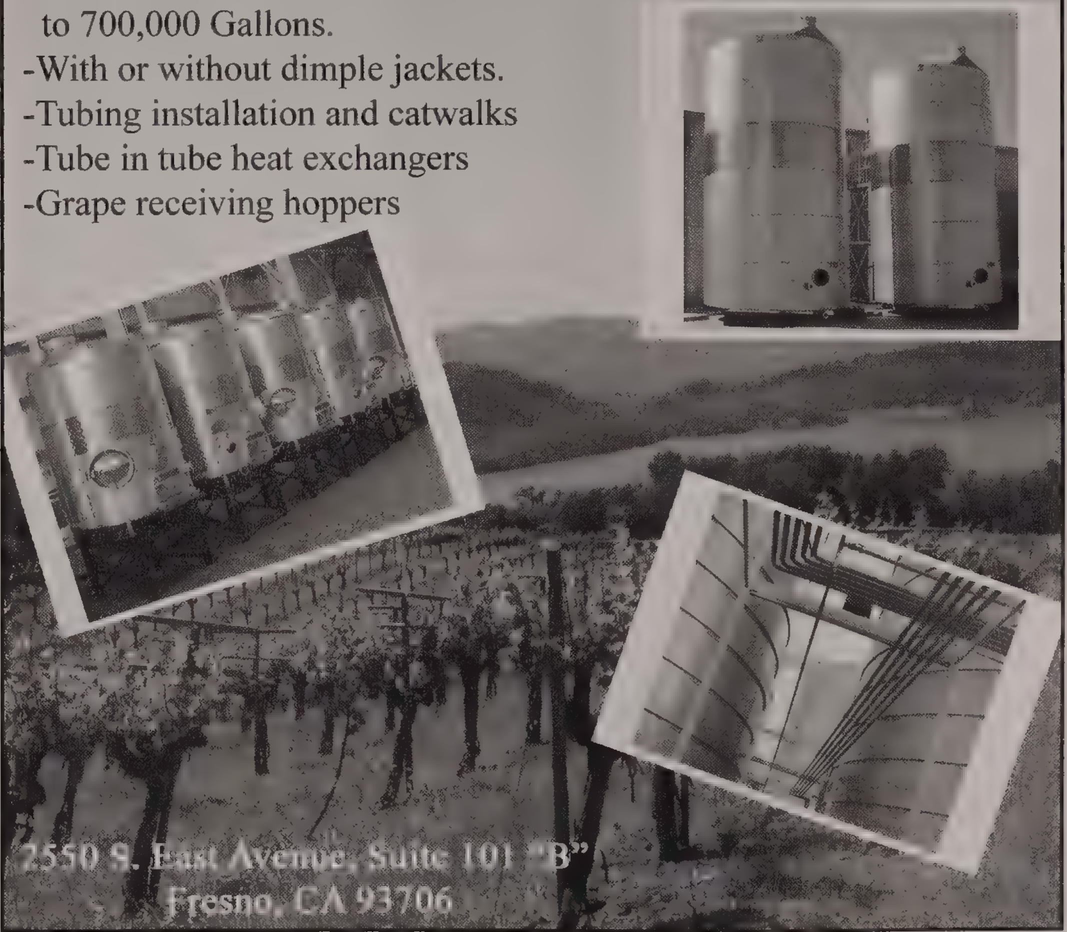

less so by taste than Higher Margin Distributors (HMD).

Margin itself and retail price point is significantly more of an influence to LMD while HMD, similar to those with an on-premise focus are more influenced by grape variety, and interestingly by medals and awards. While medals and awards have not shown to be much of an influence in consumer research,10 clearly HMD see some value in them.

Conclusion

While the limitations of this paper may be seen in the low number of respondents, in a B2b setting numbers of respondents are typically lower than in consumer research simply because there are fewer in the population. This research represents 18% of the population of the licensed distributors in Australia that sell non-proprietary brands; as such, it can be seen to be a sample worthy of examination.

As a starting point to using consumer choice modeling to understand decision making within the wine supply chain, this paper has presented data that show differences in decision making by distributors when segmenting by margin, market focus, and sales volume. Wineries and wine researchers have seen that consumers have different choice influencers in different situations and the same choice method shows differences in decisions in the supply chain.[8,10]

If wineries are looking to target on-premise as an outlet for their wine, it may well be worth considering different distribution or product offering to that which is presented to the off-premise channel; different influencers are present amongst the distributors, so different approaches may be needed.

Further research is needed to extend this study to the on- and off-premise decision makers. Results like this contribute to the understanding and identification of information necessary to reduce problems identified in agency theory that are likely to misalign supply chains.

When a winery is seeking distributor representation the data presented here suggests it is always worthwhile to understand the margin of the distributor. The "demographic" of margin size is likely to result in a different emphasis of decision factors; the product offering may need to be adjusted to suit as necessary.

To assist sustainability in the wine industry (even survival), an understanding is needed of the decision influencers at all exchange points in the industry. This will assist in enabling alignment of the supply chains and creation of value for all parties. ■

This text was first published in the Australian & New Zealand Grapegrower & Winemaker, January 2012, and is edited and reproduced here with kind per-

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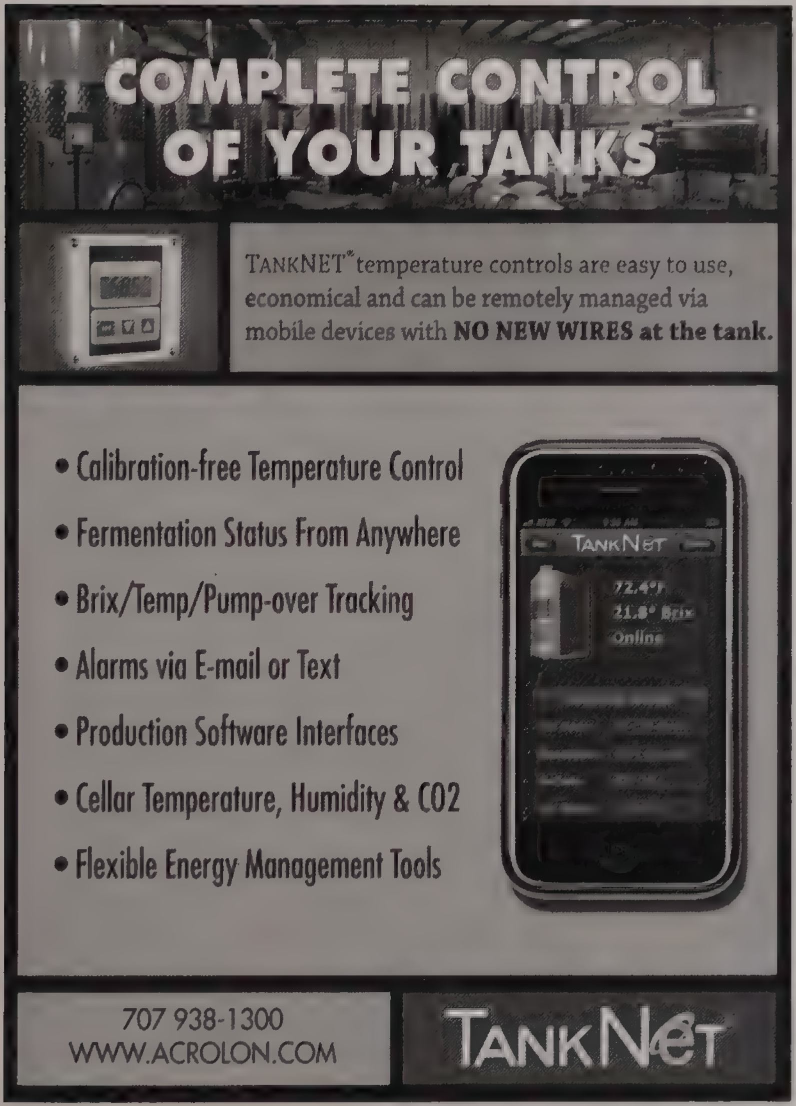
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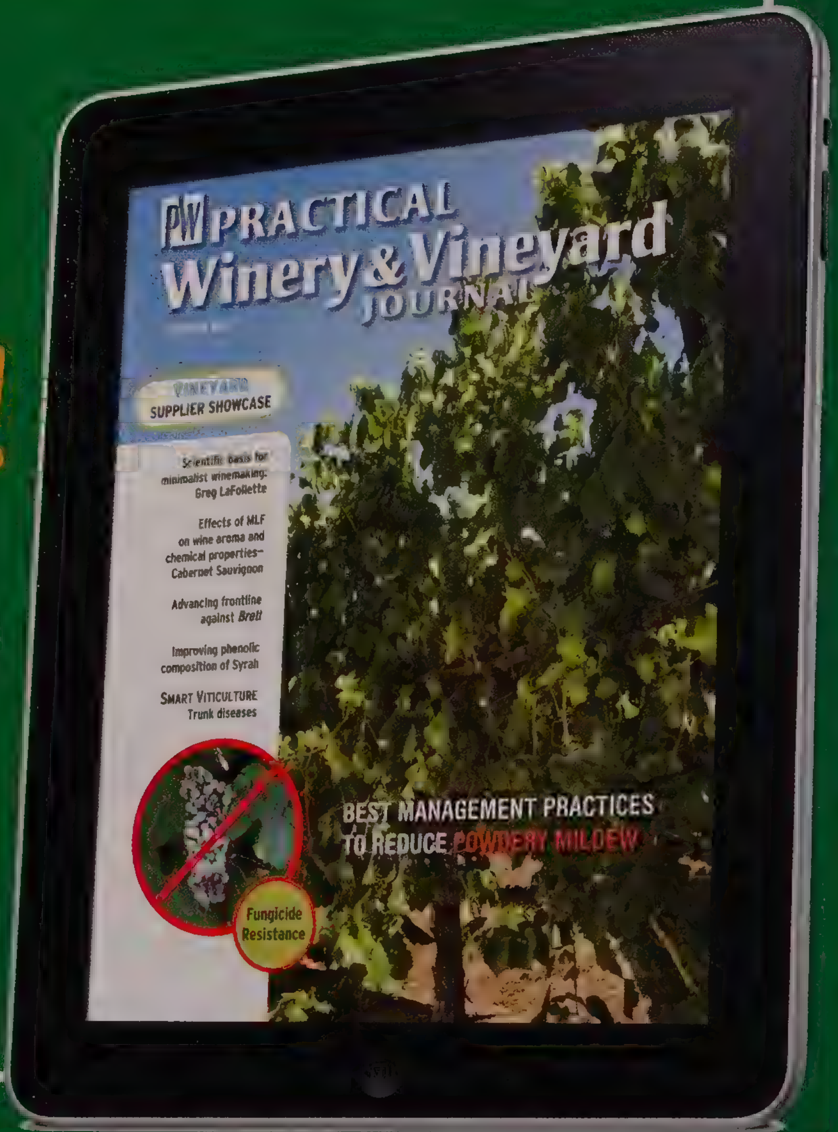
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SUMMER of Riesling

BY **Don Neel**

More than 200 restaurants in 27 states committed to offer three or more Rieslings by-the-glass in the Summer of 2011 (June 21 – September 22). The Rieslings were produced by more than 20 U.S. wineries and eleven wineries outside the U.S. The International Riesling Foundation (IRF) has more than 30 representatives from all major Riesling producing regions that hopes to have 500 participants in Summer 2012.

The IRF goal is for Riesling to be recognized and requested internationally as one of the world's most noble wines due to its diversity of styles, regional character, and compatibility with food. The IRF has developed four wine-style markers: Dry, Medium Dry, Medium Sweet, and Sweet, based on a calculation that includes the ratio of acidity to sugar and pH.

The Summer of Riesling effort was started by Paul Grieco, proprietor of Hearth and Terroir Restaurants (New York City) in 2008 in New York City and expanded to a national level in 2011.

"Oregon Riesling in general, is a niche wine," says Harry Peterson-Nedry (Chehalem Wines, Newberg, OR). "Broad-based Riesling distribution is done very well by Washington state wineries, especially Chateau Ste Michelle.

"We are growing the Oregon presence. In 2012, the number of passionate wineries is growing, but the case quantities are slower to grow. The quality of Oregon Riesling offerings is high and consistent, largely due to group technical work. Marketing efforts exist, but need to grow over time.

"The Chehalem relationship with the IRF is, as a participating winery, a part of a strategy to do joint marketing efforts like Summer of Riesling, and push the IRF perceived sweetness scale use to gain consumer friendliness for the variety, which is notorious for label obfuscation and uncertainty about sweetness. The 'Oh, I don't really like Riesling. I don't like sweet wines,' misperception has to be changed."

Chehalem wines include a Dry Riesling Reserve, a single vineyard Corral Creek Riesling, and Sext semi-sparkling reserved for cellar door and club sales. Chehalem sells Riesling wines to five Oregon restaurants and several restaurants in California. National sales of Riesling go to New York, California, Florida, Pennsylvania, and Utah.

"I believe that Riesling may, one day soon, surpass Pinot Gris in Oregon wine sales," adds Peterson-Nedry." I will very surprised, if 10 to 15 years from now, Riesling hasn't regained its dominance of the market the same as it was 20 years ago."

PWV Journal contacted Riesling producers to identify restaurants offering Riesling and food suggestions by servers.

Possibly the largest restaurant chain selling more Riesling than any other wine variety is **Pappadeaux Seafood Kitchen** (18 Texas locations), selling three Rieslings in 5-oz and 8-oz glass or bottle. Drew Hendricks [wine buyer] says that servers suggest pan-seared sea bass and blackened seafood to accompany Riesling.

The best-selling Riesling at Pappadeaux is Chateau Ste Michelle Harvest Select Riesling (10.5% alcohol, 4.98% RS, 0.89 TA, 3.0 pH). Blind Cast (a private label from Pfalz, Germany), and Penfolds "Thomas Hyland" (Australia) are available by-the-glass: 5-oz for $6, $7, $8, or 8-oz for $9, $10, $11, plus two more Rieslings by the bottle: J. Lohr "Bay Mist" (Monterey, CA), and Hugel (Alsace, France).

Paul Grieco (**Restaurant Hearth**, New York City), offers three dishes for Riesling: Escarole Salad (red onion, pecorino romano, walnuts, Bosc pear), Roasted Chatham Cod (smoked chickpeas, Tuscan kale, Baccala), and Lesso Misto (chicken thigh, house-made cotechino, short rib, veal tongue, condiments).

There are 33 **Legal Seafoods** restaurants in 10 states, all on the East Coast, the majority in the metro Boston area of Massachusetts. "In our core restaurants, we serve 6-oz pours of two Rieslings: Domaine Zind-Humbrecht 'Geuberschwihr,' Alsace, 2009 (Dry Riesling) for $11 and 2010 Gray Slate Riesling (Mosel, Germany) for $9," says Sandy Block, wine buyer.

"We identify Rieslings with perceptible sweetness on our wine list with an asterisk," adds Block. "There are four bottles of German Riesling, including one Trocken that is not sweet from the Rheinhessen; plus a Mosel, a Saar, a Pfalz; and one ½-bottle from the Rheinhessen. These are two Qbas, one Kabinett ,and two Spatlese. There are five bottles and one ½-bottle from Alsace (2005, 2006, 2008, 2009 vintages); all are dry. There is one New York State 'Dry' Riesling (Hermann J. Wiemer, Finger Lakes, 2010).

"We train Legal Seafoods servers to recommend off-dry Rieslings with dishes that have noticeable spice; one favorite is Thai Calamari. Also with dishes that have a sweet component to their flavor mix, such as the Tortilla, Apple, and Goat Cheese Salad., and with creamy textured dishes, where the Riesling's acidity can provide a refreshing counterpoint, such as our signature Crab Cakes.

Pairing Riesling with broad range of foods

By Bill Briwa

You would have to look long and hard to find a wine more agreeable and accommodating than a Riesling to pair with a broad range of foods. It has none of the oak, chewy tannins, astringency, and big alcohol of more familiar wine varieties, all of which can mean trouble at the dinner table. Riesling, by comparison, is familiar, friendly, and good-natured. Some versions are sweet, but the sweetness is nearly always balanced with delicious mouth-watering acidity. It is low in alcohol, low in astringency, fruit-forward and aromatic to make for good and lively company.

Try some of the following dishes and see for yourself:

- Crab – soft-shelled and sautéed, cracked, cakes or claws are great with a Riesling that has some weight either by sweetness or ripeness.
- Entrée salads with protein and fruit are always popular and show well with Riesling. Think Chinese chicken salad with Asian pear or Thai grilled beef salad with ginger and lime.
- Chinese food often carries some residual sweetness (think plum sauce and hoisin), but dovetails beautifully with an off-dry spätlese. The sweetness of the wine also tames reasonable levels of piquant spice.
- Other Asian specialties, like sushi, Thai curries, and Vietnamese salad rolls make compelling partners.
- A wide selection of spicy foods from Caribbean to Cajun, and Buffalo wings to curry, welcome the soothing sweetness that is Riesling. Do not overdo it however -- at some point beer just makes more sense.
- Cured meats and charcuterie like ham or sausage (brats from the grill anyone?) pâtés, terrines, and even foie gras torchon with a weightier sweet example are all delicious. (By way of full disclosure, my ancestors hail from Alsace – ***Choucroute Rocks!***)
- Smoked foods from fish to pork and all BBQ loves Riesling, but a favorite is a spectacular mid-summer, bacon-rich BLT.

Here are a couple of wine and food rules not to forget:

- Match the weight and intensity of wine and food. Riesling runs the gamut from dry, and delicate at 8% alcohol to weightier, dry to off-dry versions at 12% and even honey-sweet dessert wines still with bright, balanced acidity.
- Sweet foods should stay slightly less sweet than the wine they are served with. Remarkably, forward fruit can sometimes stand in for residual sweetness.
- Balanced wines like Riesling are easiest to pair, especially with balanced, properly-seasoned foods.

Bill Briwa is a chef-instructor at the Greystone campus of The Culinary Institute of America (St. Helena, CA). The list of things he has not tasted in pursuit of flavor is shrinking with each passing day.

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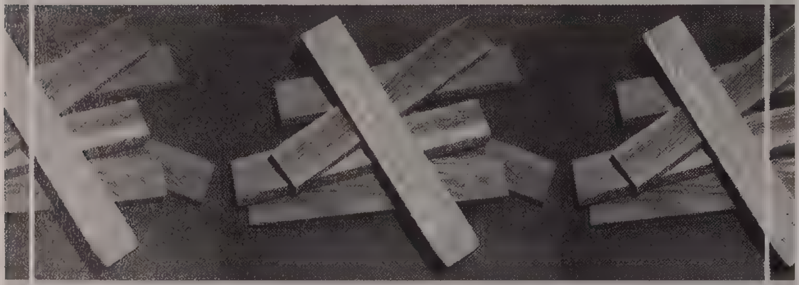

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"We have seen a significant increase in guest interest in Riesling over the past several years and, while it is not as popular as Chardonnay, Pinot Gris/Pinot Grigio or Sauvignon Blanc, it is a solid #4 among Legal Seafoods white wines."

Veraison Restaurant at Glenora Wine Cellars (New York state), has a Dry Riesling (1.2% RS, 11% alcohol) and a regular Riesling (3.2% RS, 11% alcohol). Food suggestions are: New England clam chowder, corn-crusted calamari, and pork chop with braised red cabbage, potato cake, warm cider reduction, apple frittes.

Blue Point Grill (Harbor Hotel, Watkins Glen, NY) offers seven Rieslings, reports Christine Peacock (director of sales) including two dry Rieslings, Hermann J.Weimer and Dr. Konstantin Frank as a 5-oz pour ($12) or bottle ($34). Wagner semi-sweet Riesling is available by the 5-oz glass ($6). "We sell more Riesling by the glass and bottle than any other wine. Chardonnay is second, but not very close," adds Peacock.

Blue Point Grill server suggestions are: Tuscan Chicken (pan-fried double chicken breasts with fresh spinach, artichoke hearts, and baby Portobello mushrooms over couscous with a lemon caper sauce) for the Wagner Riesling; Grilled Black Grouper over a mushroom risotto with an almond-scallion butter for the Herman J. Weimer Riesling; and Grilled Salmon braised with baby clams, endive and tortellini in a soy mushroom brood for the Dr. Konstantin Frank. Four more Finger Lakes Rieslings are available by the bottle ($24 to $32).

Stir Crazy Fresh Asian Grill has 18 restaurants in Illinois and eight other states that offer two Rieslings in a 7-oz pour or bottle. One of the top five selling Stir Crazy wines is the Chateau Ste Michelle Columbia Valley Dry Riesling (11% alcohol, 0.8 TA, 2.29% RS). Another dry Riesling is Pacific Rim Columbia Valley (12.5% alcohol, 0.75 TA, .75% RS).

Gregg Carey (owner/wine buyer), suggests two appetizers: Ahi Tuna and Avocado Poke (tower of marinated ahi tuna, avocado, red onion and sesame seeds, served with ginger-lime and sriracha sauces), and Crazy Shrimp (tender, crispy tempura battered shrimp tossed in a signature sweet and spicy sauce and served with Asian slaw); and a three-spice chicken entrée.

Anthony's Restaurants is a group of 26 restaurants in Washington state plus one in Bend, Oregon. "We specialize in fresh Northwest seafood, in-season local produce, Northwest wines, and local microbrews," says Lane Hoss, wine buyer. "No two restaurants are exactly the same but there are waterfront dinner houses, casual seafood restaurants, and 'to go' fish & chip bars.

"Riesling has been a significant player in our wine selections for 25

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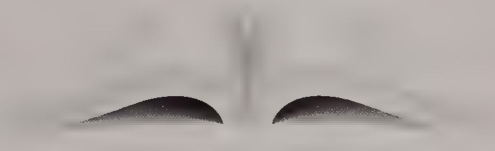

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years and always has the top 2 or 3 sales position in wine by-the-glass (7oz) sales. We may offer up to three Rieslings by the glass when we feature fresh seafood dishes that match well with Riesling.

The most prevalent wine is Chateau Ste. Michelle Columbia Valley Riesling that is offered in many of our restaurants by the glass and bottle. We also serve Chateau Ste. Michelle Cold Creek Vineyard, Eroica, and Snoqualmie Winery Rieslings. Four more Washington Rieslings are Milbrandt Vineyards Traditions, Dunham Cellars Lewis Estate Vineyard, and Poet's Leap. Chehalem Dry Riesling is available in our Bend, OR restaurant..

"Riesling is delightful with whole Dungeness crab simply steamed or served chilled. The delicate fruit flavors of the Chateau Ste. Michelle Riesling complement the wonderful sweet flavor of our local crab. Riesling compliments our Dungeness Crab Cakes (which are made without filler – simply crabmeat) served with a ginger plum sauce and beurre blanc. Other matches include asian-influenced preparations of scallops, prawns, and Dungeness crab. Our signature Hawaiian ahi nachos with mango chutney and tempura ahi roll are other seafood examples. The slight sweetness and pronounced fruit of Northwest Riesling is a favorite match for our spiced blackened fresh ling cod, rockfish, or halibut." ■

Controling Powdery Mildew

Continued from page 14

not on new leaves that emerge after the last application. No kidding.

- However, sulfur provides excellent post-infection control when applied up through the time that young colonies start to become obvious (about six or seven days at .80°F). Although it does have some eradicant activity against raging infections (see below), it is significantly stronger against the younger colonies. Practically speaking, this means that when a PM spore lands on a new, unprotected leaf produced since the last application (see above), there is still time to hit it with the next spray in a post-infection mode if that is applied thoroughly and before mildew is easy to see. Australian researchers have reported similar results.
- As noted above, post-infection sprays applied to heavily-diseased tissues are much less effective than those applied to incubating or very young colonies. Sulfur is not the material of choice as an eradicant if you reach the "Omigod!" stage. That would be Stylet Oil or the similar PureSpray Green (or perhaps Oxidate, at a much higher cost).

Remember that once the leaf or berry cells beneath a well-established mildew colony have been sucked dry by the fungus, nothing will bring them back to life even if the mildew is eradicated. The best that an eradicant spray can do is to keep things from getting much worse, it cannot raise the dead. Never forget that the results you obtain will only be as good as the spray coverage you can provide.

- We were unable to demonstrate any negative effects of low temperatures on either the protective or post-infection activities of sulfur. In a number of repeated tests, control was the same at 59°F as it was at 82°F when we sprayed with the equivalent of 5 lb/A of Microthiol. Workers from Australia also reported no differences in control at 59°, 68°, or 86°F when used at this rate, although there was a slight decrease in activity at 59°F when the rate was reduced down to 1.7 lb/A.
- Rainfall of 1 to 2 inches decreases sulfur's protective activity significantly. Not surprisingly, this effect is more pronounced with generic "wettable" formulations than with so-called "micronized" formulations (e.g., Microthiol), which have smaller particle sizes so adhere better to tissue surfaces. These latter formulations cost more for a reason. The negative effects of rainfall can be somewhat compensated for by adding a "spreader-sticker" adjuvant to the spray solution and/or increasing the application rate. ■

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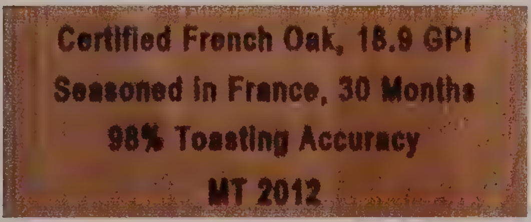

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For more information, contact: Cooperages 1912 Napa, tel: 707/255-5900, www.cooperages1912.com.

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"GTREE™ is a cost-competitive bright white, uncoated sheet which offers excellent embossing and hot foil stamping performance," says Fred Dale, G3's Label Division senior manager for technical service and quality control.

For more information about GTREE™, visit www.G3Enterprises.com.

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Enartis MicroOx is available with 1, 2, 5, and 10 dosing points. Upon request, customized systems can be manufactured.

Max Buiani is the contact at Enartis Vinquiry for more technical information, 707-838-6312.

Overcoming fungicide resistance

Continued from page 15

Examples of qualitative resistance include that to the to the benzimidazoles (Benlate and Topsin-M) among many populations of the powdery mildew and Botrytis bunch rot fungi around the world; to the the QoI or strobilurin fungicides (such as Abound, Flint, Sovran, one component of Pristine) among many populations of the downy mildew pathogen where this disease is a problem and among some populations of the powdery mildew fungus in the eastern United States and beyond; and to the phenylamides (Ridomil) among many populations of the downy mildew organism where such materials have been used intensively.

When resistance is quantitative, individuals poorly controlled by one dose (or rate, loosely speaking) of the material may be controlled by incremental increases in that dose or substitution of a similar dose of a related material that has greater intrinsic activity (such as 1 mg of Fungicide B provides more control than 1 mg of Fungicide A). In this case, the sensitivity distribution within the pathogen population shifts incrementally after repeated use of the same class of materials, with progressively greater proportions of the fungal individuals requiring progressively higher doses of the material for a given level of control ("displacement" shifts).

A well-characterized example of quantitative resistance is that to the demethylation inhibiting (DMI) fungicides among populations of the powdery mildew fungus, which is common worldwide.

Basic resistance management strategies include:

- Limit the number of selection events, i.e., limit the number of applications of an at-risk fungicide or related products having the same biochemical mode of action. Many fungicide labels now designate a numerical group to which that material has been assigned on the basis of its biochemical mode of action. This is meant to help growers and advisors identify commercial products that can and cannot be rotated with one another for resistance management purposes.
- Limit the size of the pathogen population from which you may be selecting resistant individuals, thereby limiting the potential number of resistant survivors. Avoid using a material at high risk of resistance development as a "rescue" (eradicant) treatment in a vineyard with a severe outbreak of the target disease.
- Limit the reproduction of resistant individuals that have survived exposure to the at-risk fungicide. This can be accomplished several ways:

i) Utilize appropriate cultural practices to limit disease development (pathogen reproduction).

ii) Rotate with effective, unrelated fungicides; the fewer sequential applications of an at-risk fungicide in favor of alternating with an unrelated material, the less opportunity for reproduction of resistant individuals before they are controlled by something else.

iii) Apply in combination with another unrelated fungicide, either through tank mixing or use of a prepackaged product containing two or more active ingredients. Be aware that resistance management efforts dependent upon rotation and/or combination with unrelated fungicides are only as effective as the companion materials themselves; a weak companion material or low use rate will have a limited effect on slowing reproduction of resistant individuals that have survived exposure to the at-risk ingredient.

- An additional strategy appropriate to fungicides subject to quantitative resistance (DMI materials) is to reduce the proportion of the pathogen population that is resistant to an application of them. This can be done by increasing the activity of the application, either by increasing the rate of the product to a legal maximum or substituting a related fungicide having greater intrinsic activity. Maximizing spray coverage will also maximize the dose of product encountered by fungal targets at any given rate of application.

Strobilurin ("Group 11") fungicide resistance, reminder, and update

Strobilurin (strobie) resistance started causing a problem with powdery mildew (PM) control in the Finger Lakes and Long Island regions of New York in 2002. For several years, Dr. Anton Baudoin (Virginia Tech) has reported PM resistance from select mid-Atlantic vineyards, and there is a recent report suggesting control failure due to resistance in an Australian vineyard. Downy mildew (DM) resistance has become so widespread in many mid-Atlantic and southern regions that these materials are no longer relied upon there for control of DM. Similarly, the strobies are no longer effective against DM in many European regions where this disease occurs regularly.

We have received anecdotal reports of poor DM control with strobie products from several regions of New York, and had a failure after multiple, season-long applications (not recommended!) in one recent trial at Geneva. Thus, real caution is in order when considering potential strobie utility against DM in New York and other more northerly areas where problems have not yet become apparent or only occur erratically.

On this same note, other regions that have not yet encountered problems with powdery mildew would be well advised to learn the same lessons that we have when it comes to guarding against "surprise" failures to control this disease. The question regarding development of resistance to these materials is one of "when," not "if." How you use them will determine whether the answer to this question is "when I am old(er) and gray(er)" or "any day now."

Control failures due to strobie resistance typically occur suddenly and without warning in an affected vineyard. As noted above development of fungicide resistance is a simple but classical illustration of the principles of evolution (natural selection), a "survival of the fittest" for individuals within a fungal population that is treated with the material.

How quickly these individuals come to dominate the population to a point that the material no longer works well when used properly (i.e., not because you sprayed incorrectly or pushed the envelope too far) depends primarily on a) the number of spray applications imposed on the population, and b) the ability of the "selected" (resistant) individuals to multiply and spread.

This multiplication and spread is determined by a number of factors, including 1) the number and intensity of potential infection events (the weather); 2) the relative ability of the disease-causing fungus to grow and reproduce on the particular vine (varietal susceptibility); 3) the inherent "reproductive capacity" of the fungus (the time between initiation of infection and production of a new generation of spores, and the relative number of spores then produced); 4) the extent to which these spores are dispersed over distance, to start their dirty work elsewhere; and 5) the degree to which reproduction is arrested (disease is limited) by other farming practices, including non-chemical means and applications of effective, unrelated fungicides in rotation and/or tank mixture.

The above somewhat self-evident principles explain a lot about our recent history with strobie resistance, where we are likely to go with it in the future, and the options that we have at our disposal to address it.

For example: 1) Why PM resistance occurred in New York more quickly than DM resistance (a run of dry years shortly after introduction of the strobies — 1998, 1999, 2001, 2002 — that favored reproduction of PM but not DM);

2) Why resistance to DM rather than PM is a greater problem further south (warmer temperatures are more favorable to DM reproduction and spread; also, we started aggressively limiting strobie use in PM land earlier in the game, due to the 2002 PM resistance wake-up);

3) Why the first PM problems were on Chardonnay (optimum pathogen reproduction);

4) Why the initial problems were so much less common in vineyards that had tank-mixed with sulfur (less reproduction of the strobie-resistant individuals that were selected, i.e., survived applications of those materials); and

5) Why nobody has yet encountered black rot [BR] resistance (BR has a much lower reproductive capacity than PM and DM — it takes two to four times longer for infections to produce new spores [hence, fewer generations per year] and new BR spores are dispersed only a matter of feet by splashing raindrops, compared to new PM and DM spores that are spread far and wide by wind currents).

It is imperative to limit the use of these products if you want them to remain effective — no more than two sprays per season is our recommendation in New York. If using a strobie product to control PM, the best option for most growers is either to use Pristine (at labeled rates, it contains enough boscalid -- the non-strobie component of the product -- to provide control by itself) or tank-mix with sulfur if using one of the other strobie materials. Tank-mixing sulfur with Pristine is a good idea, too, in vineyards where the strobie portion is or might be compromised, in order to protect the non-boscalid component.

For other combination products that might come along -- and they are the current trend in the fungicide industry -- make sure that the rate of the non-strobie component that is provided is adequate to control PM if the strobie portion fails. For example, Adament contains the strobie ingredient, trifloxystrobin (Flint) plus the DMI ingredient, tebuconazole (Elite).

However, the Adament rate labeled for PM control is 3 oz/acre, which provides the same dose of tebuconazole as 1.67 oz of Elite, which is only 42% of the rate recommended when using Elite or generic tebuconazole products alone. This amount is unlikely to provide adequate control of strobie-resistant PM colonies should they occur, especially in vineyards with a long history of DMI use.

The boscalid component of Pristine does not provide any appreciable control of downy mildew, so even this product must be tank-mixed with an effective DM fungicide to be safe in regions where DM resistance has begun to appear -- a recommendation that is a lot easier to make if it is not your own money being used to buy the second material. Nevertheless, the bottom line is, the strobies are no longer viable DM materials in significant portions of the eastern U.S., and using them alone to control this disease is a gamble. ■

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IN-DEPTH LOOK AT

John Gladstones' Wine, Terroir & Climate Change

Review by Brian Croser, TapaNappa Wines, Australia

This is a wonderful book in two parts. I deal here with the *Wine and Terroir* part of the book, which is contained in the first eleven chapters and then again in chapter 14, *21st century viticulture and its terroirs: a summary.* I will review chapters 12 and 13 on *Climate Change* and its potential effects on viticulture as we know it separately.

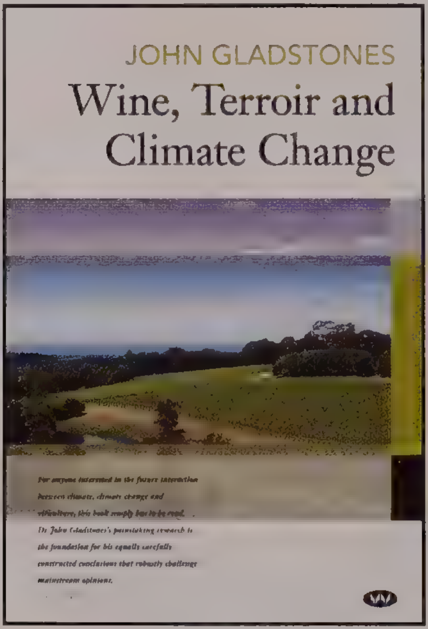
The great contribution this book makes is that it carefully integrates what we know about the many elements of the viticultural environment with the physiological mechanisms of the vine's response and their effect on grape composition and then on wine style and quality. That is the holy grail of knowledge for a vigneron trying to understand terroir.

John Gladstones works to a sensible and uncontroversial definition of *terroir*: "That is, simply, the vine's whole natural environment, the combination of climate, topography, geology, and soil that bears on its growth and the characteristics of its grapes and wines" (page 2).

Gladstones does not only set out to explain how terroir works. That happens along the way. A main purpose for the book is much less ambitious: to create a systematic template to measure that part of the growing-season heat of an individual location which affects the time of harvest and allows prediction of the harvest date for the range of varietal maturation groups in that site.

For any location, given the average maximum and average minimum temperatures for each of the seven months of the growing season (northern hemisphere March to October, southern hemisphere October to March); the latitude; altitude; degree of slope and inclination to the sun; soil type (depth, drainage, calcareous, stoniness); and surrounding topography (isolated hill or ridge, inland, near a lake or the sea etc.), a calculation can be made of the heat which affects the phenology of the vine; its growth rate and the timing of flowering, fruit set, veraison and, ultimately, harvest. Gladstones calls this heat "the biologically effective degree days, E°days." A prediction can be made of the average harvest date for each maturity group of winemaking varieties from this calculation.

He describes "Grape variety maturity groups and E°days needed for their maturation" in Table 10.1 (page 100) based on empirical knowledge of grape varieties from many sources.



JOHN GLADSTONES

Wine, Terroir and Climate Change

For anyone interested in the future interaction between climate, climate change and viticulture, this book simply has to be read.

Dr John Gladstones's painstaking research is the foundation for his equally carefully constructed conclusions that robustly challenge mainstream opinions.

In a working example, Gladstones sets out the site-temperature adjustment factors in Table 2.2 (page 15) and applies those adjustments to the base temperature data for a typical vineyard site in the Canberra region in Table 11.3 (page 123). He then compares that vineyard heat accumulation data to the heat requirement to ripen each grape-variety maturity group to predict a harvest date for each maturity group in that location, Table 11.4 (page126).

Central to the estimation of harvest dates is an understanding of how temperature affects the rate of phenological development of the vine.

Gladstones' hypothesis of phenology

His central hypothesis concerning the rate of phenological development of the grapevine is that this rate is maximized at 19°C. Hence only those months with a mean temperature of less than 19°C and in particular the night temperatures of those months, influence the timing of phenological events (pages 6-7).

For most locations, it is the suboptimal temperatures for phenological development of the first two to three months of the growing season that determine the time of flowering and set. Cool conditions retard and warm conditions accelerate flowering. After flowering occurs, mean temperatures are greater than 19°C, phenological development rates are maximized, and the time between flowering and harvest is the same regardless of the temperature of the later ripening months.

This hypothesis has implications for sites with large daily temperature ranges. The low night temperatures of these sites act as a brake on the phenological development of the vine, predicating later flowering and harvest than would otherwise be expected (pages 7-8).

The understanding of the drivers, and the accurate prediction, of harvest dates for varieties and sites is a considerable contribution to viticultural understanding. However, that is a minor contribution in the context of the other insights this book provides.

The greater logic of the book lies scattered through the chapters on the various elements of terroir and how they have an impact on the physiology of the vine and grape to impart a terroir thumb-print on wine style and quality.

Gladstones' hypothesis of temperature equability

The central role of atmospheric temperature of a vineyard site being a major determinant of wine quality and style is well understood (Chapter 2). Further to this accepted wisdom, Gladstones advances the hypothesis that a low daily range of temperature during the growing season defines the best viticultural sites and creates the best wine quality (pages 24-25).

Sites with narrow daily temperature range are usually maritime or at high latitudes (pages 38-39) and have intrinsically lower temperature variability and hence more immunity from frost and heat damage. They also have higher humidity with lower rates of transpiration and hence of sugar transfer into the ripening fruit (page 30). The lower rate of sugaring in humid climates allows flavor and tannin ripeness to occur at lower sugars and hence at lower wine alcohol.

Narrow daily range sites also have higher night temperatures allowing

details, details, details

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Wednesday May 2

Keynote Speaker: **Rowan Jacobsen,** Author, American Terroir: "The Real Dirt: Why Terroir's Time Has Come"

Rachel Laudan, Historian/Freelance Writer; Author of *Cuisine and Empire: A World History of Food* (forthcoming, University of California Press): "Back to the Beginning: When and Why the French Invented Terroir"

Chocolate and Terroir

Frederick Schilling, Founder/CEO, Dagoba Chocolate: "The Subjective and Objective Nature of Terroir in Cacao/Chocolate"

Howard Shapiro, Global Director for Plant Science and External Research, Mars, Inc.; "Cacao Terroir: From Fact to Fiction"

Alexandra Saunders, Nuubia Chocolat (Pleasanton, CA): "A Sense of Awe and the Terroir of Chocolate"

All about Wine

Randall Grahm, Founder, Bonny Doon Vineyard (Santa Cruz, CA)

Ken Bernard, Owner/Winemaker and **Curtis Strohl,** Ancien Wines (Napa, CA): "Exploring Layers of Terroir with Pinot Noir"

Andy Erickson, Co-Owner, Favia Wines (Napa, CA)

Alan Busacca, Alma Terra Wines (Bingen, WA): "Effect of Spatial Scale and Soil Variability on the Expression of Terroir: Pacific Northwest U.S."

Kees Van Leeuwen, professor, Ecole Nationale des Ingénieurs des Travaux Agricoles (ENITAB), Bordeaux, France

Alex Maltman, Geologist, Institute of Geography and Earth Sciences, University of Wales

Kevin Pogue, Professor of Geology, Whitman College (Walla Walla, WA and Owner, Vinterra Consulting Walla Walla, WA)

Film Presentation "Wine from Here-Natural Wine in California"

Thursday May 3

Terroir of Most Everything Else

George Howell, George Howell Coffee Co. (Acton, MA): "Coffee"

Kevin Gascoyne, Black Tea Specialist for *Camellia Sinensis*, (Montreal, Canada): "Tea"

Naomi Novotny, SaltWorks (Woodinville, WA): "Salt"

Richard Waycott, Almond Board of California (Modesto, CA) "Almonds"

Marina Marchese, Red Bee Apiary (Weston, CT) "Honey"

Moshe Rosenberg, Professor and Specialist, Dairy Engineering & Technology, (Dept of Food Science & Technology, UC Davis) "Cheese"

Travis and Ryan Croxton, Rappahannock River Oysters, (Topping, VA) "Oysters"

Ken Verosub, Distinguished Professor, (Dept of Geology, UC Davis) "Bottled Water"

Douglas B. Walsh, Professor of Entomology / Research Director, Environmental & Agricultural Entomology Laboratory (Washington State University) "Hops"

Mauro Carbone, Director, National Centre for Truffle Studies, Alba, Italy "Truffles"

Defining/Regulating/Marketing Terroir

Justin Hughes (Yeshiva University) "How the Law Misunderstands (and Manipulates) the Idea of Terroir"

Dev Gangjee (Law Department, London School of Economics) "A European Perspective on Protection for Geographical Indicators"

Isabella Oddero, Oddero Poderi e Cantine (La Morra Cuneo, Italy) "A Winemaker's Experience with DOC, DOCG and DOP Regulations in the Langhe, Piedmont, Italy"

Jane Killibrew-Galeski, Anheuser-Busch/InBev (St. Louis, MO) "The Art and Science of Water Management for Brewing"

Investigating/Understanding Terroir

Rosa Lamuela (University of Barcelona) "How Soil Affects White Wine Quality by Altering a Vineyard's Ecosystem"

Soon Lee (University of Auckland) "Is there a Microbial Aspect to Terroir?"

Rachel Dutton (Harvard University) "Microbiology of Cheese"

Adam Gopnik (New Yorker Staff Writer and Author) "The Table Comes First: Family, France, and the Meaning of Food"

Special Terroir Conference Dinner

Friday, May 4

Experiencing Terroir

Hildegard Heymann and **Sue Ebeler** (UC Davis) "Sensory Perception and the Chemical Analysis of Regionality"

Genevieve Teil, Centre Régional de Recherche Agronomique Station Expérimentale de Boukhalef (Tanger, Marocco)

Changing Terroir

Greg Jones (Southern Oregon University) "Terroir of Wine: Stable or Fragile in a Changing Climate?"

Gary Nabhan (University of Arizona) "The Scrambling of Terroir: Chile Peppers and Climate Change"

Terroir Tasting Fair

Hosted by: Robert Mondavi Institute for Wine and Food Science
UC DAVIS DEPARTMENT OF GEOLOGY

Enhancing the quality of life through wine, brewing and food sciences respiration and flavor and tannin synthesis to occur at night and during the day (page 25). This results in more rapid and complete ripening of the fruit again at lower sugars.

The corollaries of Gladstones' narrow daily range hypothesis are:

- "The best fruit and wine quality almost invariably follows rapid flavor ripening,"
- "The greatest vineyards are almost always in the topographic and mesoclimatic situations with best night air drainage and therefore lowest diurnal temperature range,"
- "The best wines come from the warmest sites in the coolest climates,"
- "On average, the best wines also come from the warmest seasons, when the grapes ripen early" (page 26).

Root control of terroir expression

Recognizing the pivotal role of climate in the appropriate choice of variety for a site and climate's influence on the canopy and fruit in the ripening process (Chapter 2), a more hypothetical case is made for the role of the underground environment and the health and response of the root system being central to the expression of terroir and the achievement of quality (Chapter 5).

Referencing the large and often contradictory literature on hormone activity in grapevines and their influence on phenology, Gladstones hypothesizes with conviction based on experimental evidence that the roots are central in the achievement of quality and a unique expression of a terroir and for that to happen the vine's root system must be mature (page 52). Mature means the vine's roots are filling the whole soil space available to them, down and into the soil-rock boundary (lithosphere), where soil is being formed, and potentially into the rock itself in soils formed in situ on a local geology.

Gladstones' hypothesis on root control of ripening

"Soils that warm readily, and to the greatest depth, are a universal part of good viticultural terroir" (page 51).

Gladstones explains the role of root-derived hormones in vine growth and grape ripening (pages 57-58). The soil temperature and moisture availability throughout the soil profile control the formation of hormones in and behind the growing root tips, which in turn control the growth, fruiting, and ripening processes in the aerial parts of the vine. Initially the hormones are carried to the shoots, leaves, and fruit by the sugar and nutrient-transferring phloem system. The evidence is that without a constant stream of these trace signal and control hormones from the roots, seeds, and leaves, all growth and ripening processes stop.

As the soil warms up in the early Spring, fine roots begin to grow out from the permanent root architecture, ideally in a soil that is at full water capacity at that stage but has the composition and drainage structure to be aerobic. This condition of water luxury and gradual soil warming initiates the early spring flush of root growth and produces from the root tips a supply of the hormone gibberellin.

Gibberellin is the growth hormone of plants. The shoots emerging from the buds into the Spring air are triggered by gibberellin to elongate and form the aerial architecture of the vine. If the condition of water luxury and relatively cool soil persists through the spring, gibberellin remains in control and the shoots continue to elongate rapidly with very long internodes and forming very big leaves, a condition of excess vine vigor.

If the right dynamics prevail in the soil system, the drying and warming of the soil from the top down through Spring allows the balancing production and transport of another class of hormones from the roots to the canopy, the cytokinins.

Cytokynins are the fruiting hormones, which work against gibberellin and continued elongation of the internodes, forcing shoots to form nodes and leaves and causing shoots and leaves to thicken up. Cytokinins stimulate the fruiting structures (flowers) to form properly both on the current growing shoots (this year's crop) and in the developing buds in the axils of the leaf and stems (next year's crop). Cytokinins are critical to the health and fruiting process of the vine and also control the not so helpful branching or lateral shoot formation from the newly-formed buds on vines growing too vigorously.

The ideal result of the continued warming and drying of the soil profile from the top down through the flowering and fruit-set period is to create increasing water stress on the surface soil roots, forcing the vine to rely increasingly on the more tightly-held reserves of moisture deep in the clay subsoil and by capillary action from water-bearing rock structures accessed by deep roots. This increas-

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ing water stress on the roots reduces the formation of gibberellin and cytokinins, stops shoot growth, and stimulates the formation of abscisic acid.

Abscisic acid is the ripening hormone, which precipitates veraison in the fruit. At and from veraison onward a constant strong stream of abscisic acid from the roots is required to identify the ripening fruit as the strong sink for leaf-produced sugar and root-derived nutrient and to develop the color, tannins, and flavor of ripe grapes.

Excess crop acts to limit root growth by restricting assimilate transfer to the roots. This reduces root growth and the strength of the abscisic acid signal to the fruit to the detriment of the ripening process and grape and wine quality.

The ideal dynamics of soil moisture availability to the vine's roots through the growing season is one of the defining characteristics of great terroir and is a unique circumstance difficult to emulate with the root-zone limiting actions of irrigation.

Gladstones explains the ideal rainfall pattern and soil moisture response to achieve the best growth and ripening response from the root-derived hormones through the growing season (page 29). This is followed by a discussion of the limitations of, and the best strategies for irrigation in irrigation-dependent climates (pages 65-67). ■

More of this in-depth review will appear in *PWV Journal*, Summer 2012

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